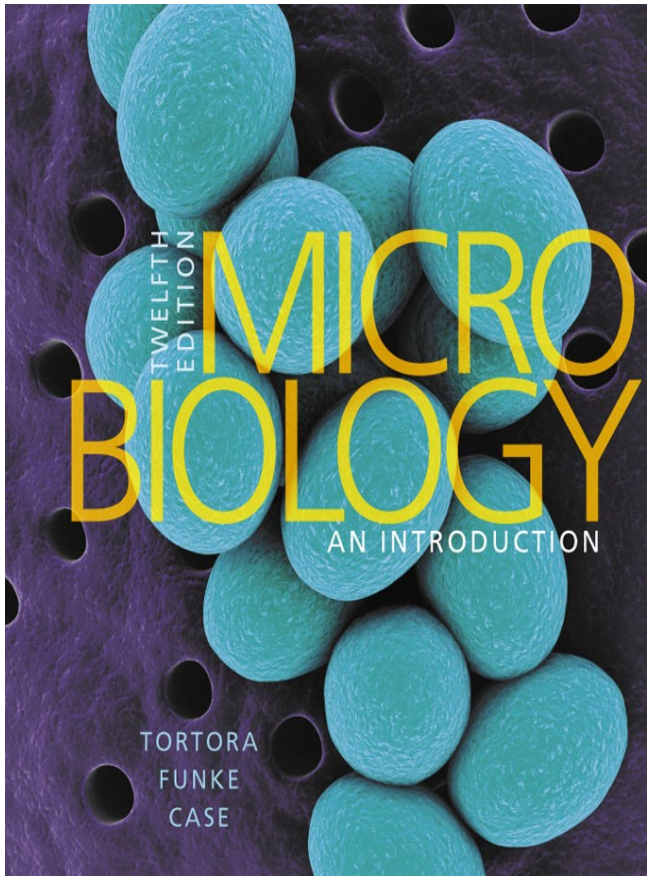
Microbiology an Introduction

Twelfth Edition

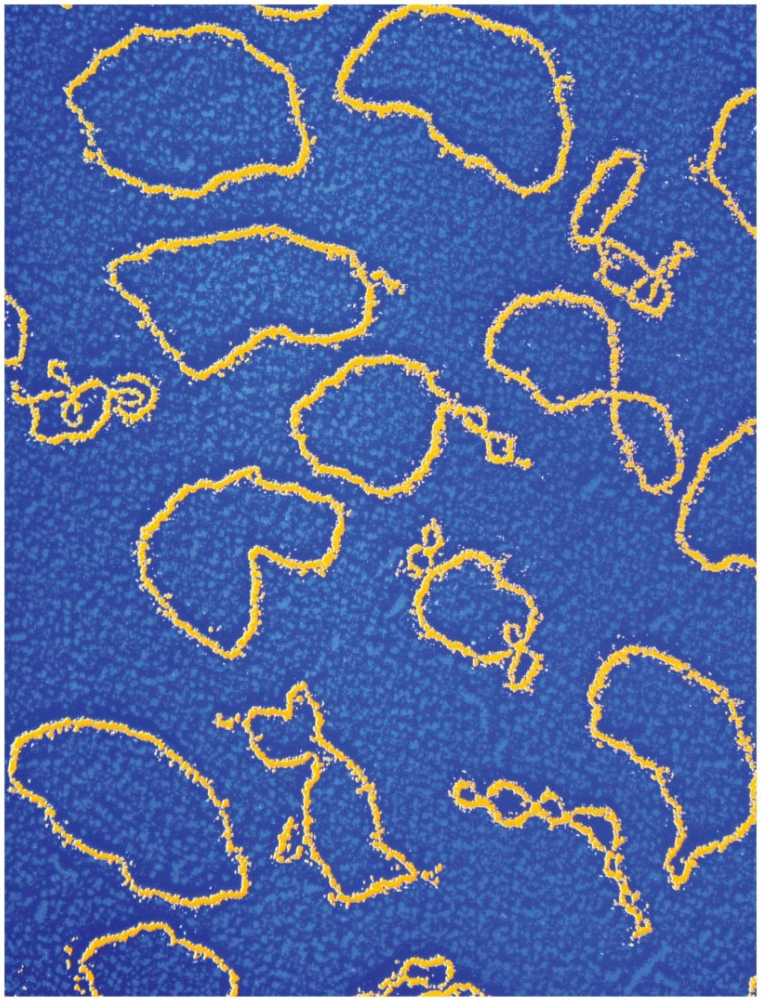


Chapter 8

Microbial Genetics

Pearson

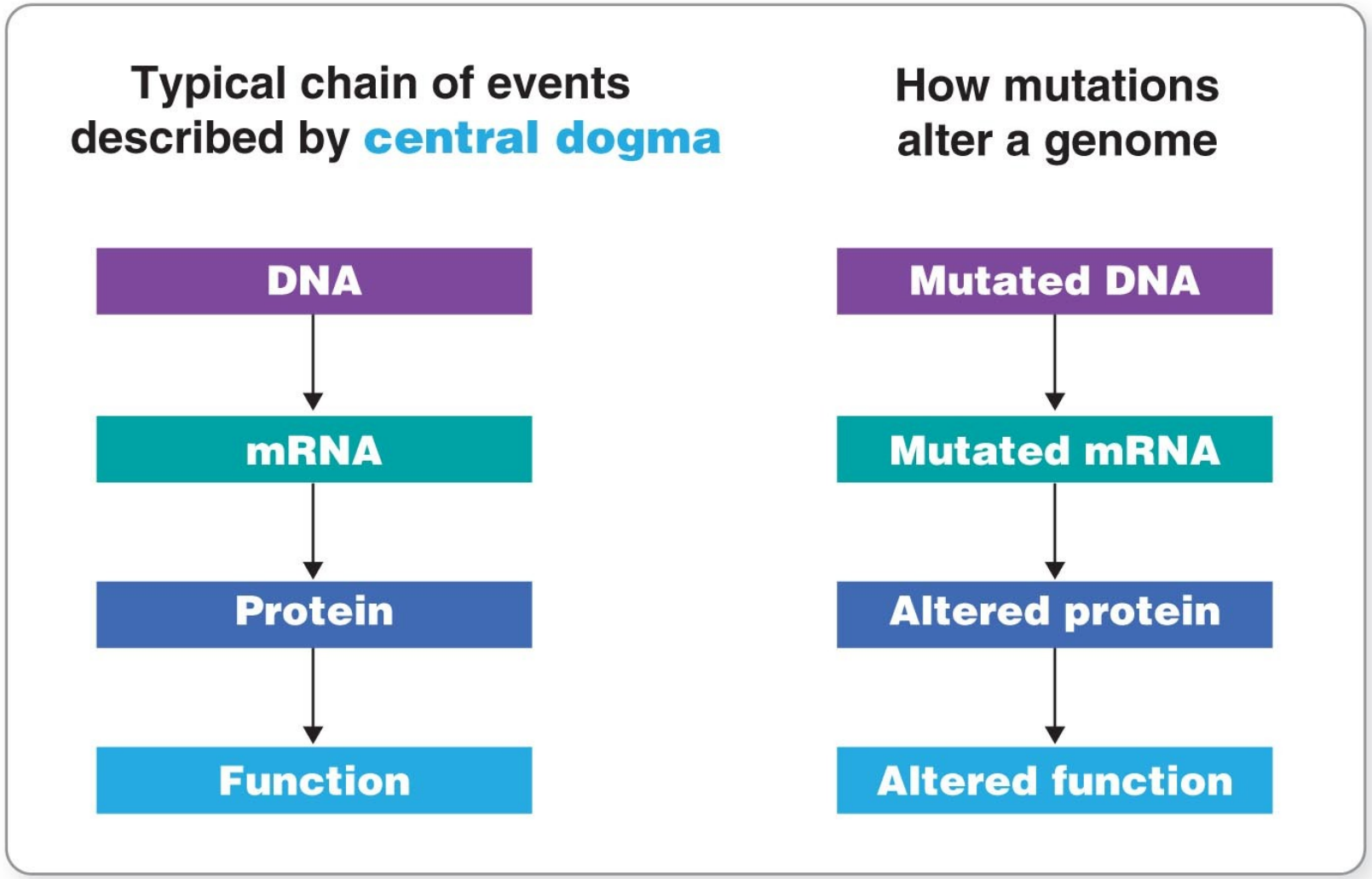
Plasmid DNA from E. coli



Big Picture: Genetics (1 of 2)

- The science of heredity
- Central dogma of molecular biology
- Mutations
- Gene expression controlled by operons

Big Picture pg. 202 (1 of 3)



Big Picture pg. 202 (2 of 3)

In **base substitution mutations**, a single DNA base pair is altered.

In **frameshift mutations**, DNA base pairs are added or removed from the sequence, causing a shift in the sequence reading.

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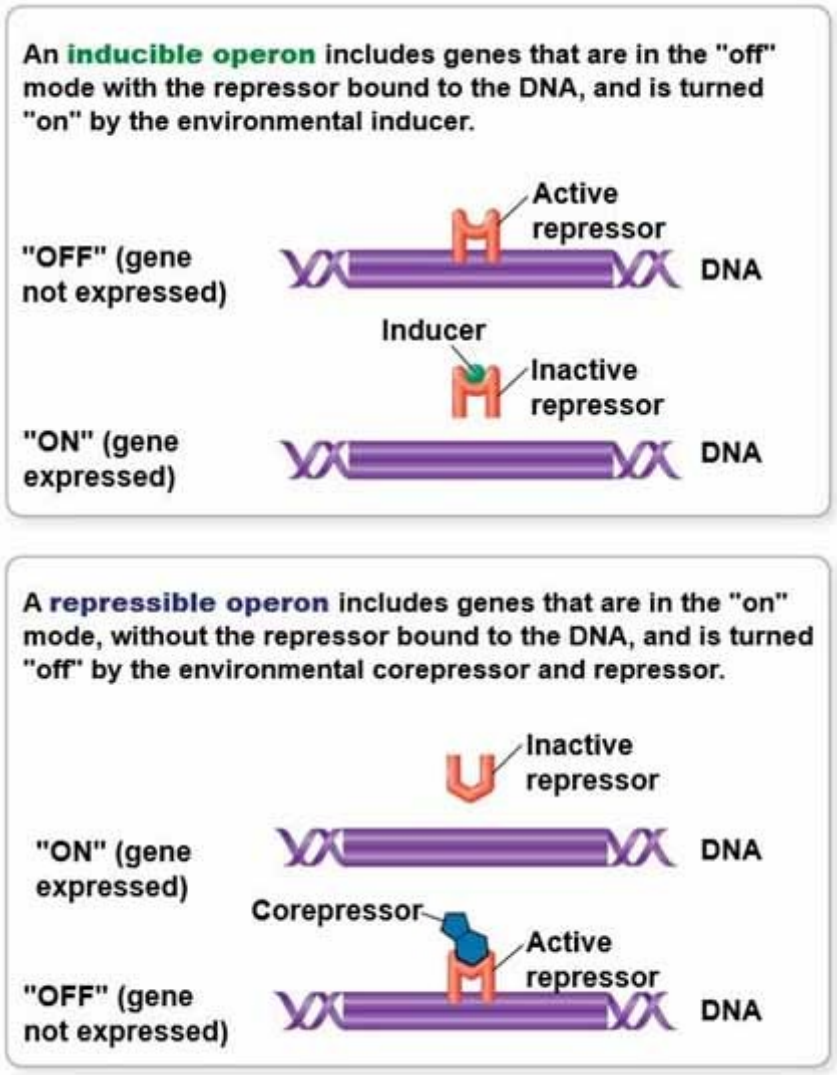
Big Picture pg. 202 (3 of 3)



Big Picture: Genetics (2 of 2)

- Alteration of bacterial genes and gene expression
  - Cause of disease
  - Prevent disease treatment
  - Manipulated for human benefit

Big Picture pg. 203

Diseases: Many bacterial diseases are caused by the presence of toxic proteins that damage human tissue. These toxic proteins are coded for by bacterial genes. *Vibrio cholerae*, shown above, produces an enterotoxin that causes diarrhea and severe dehydration, which can be fatal if left untreated.

Antibiotic Resistance: Mutations in the bacterial genome are one of the first steps toward the development of antibiotic resistance. This process has occurred with *Staphylococcus aureus*, which is currently resistant to beta-lactam antibiotics such as penicillin. Methicillin was introduced to treat penicillin-resistant *S. aureus*. Methicillin-resistant *S. aureus*, (MRSA) shown in purple above, is now a leading cause of healthcare-associated infections.

Biotechnology: Scientists can alter a microorganism's genome, adding genes that will produce human proteins used in treating disease. Insulin, used for treatment of diabetes, is produced in this manner.

KEY CONCEPTS

- DNA expression leads to cell function via the production of proteins.
- DNA expression can be controlled by operons.
- Mutations alter DNA sequences.
- DNA mutations can change bacterial function.

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Structure and Function of the Genetic Material (1 of 3)

Learning Objectives

8-1 **Define genetics, genome, chromosome, gene, genetic code, genotype, phenotype,** and **genomics**.

8-2 Describe how DNA serves as genetic information.

8-3 Describe the process of DNA replication.

8-4 Describe protein synthesis, including transcription, RNA processing, and translation.

8-5 Compare protein synthesis in prokaryotes and eukaryotes.

Structure and Function of the Genetic Material (2 of 3)

- **Genetics:** the study of genes, how they carry information, how information is expressed, and how genes are replicated
- **Chromosomes:** structures containing DNA that physically carry hereditary information; the chromosomes contain genes
- **Genes:** segments of DNA that encode functional products, usually proteins
- **Genome:** all the genetic information in a cell

Structure and Function of the Genetic Material (3 of 3)

- The **genetic code** is a set of rules that determines how a nucleotide sequence is converted to an amino acid sequence of a protein
- **Central dogma:**

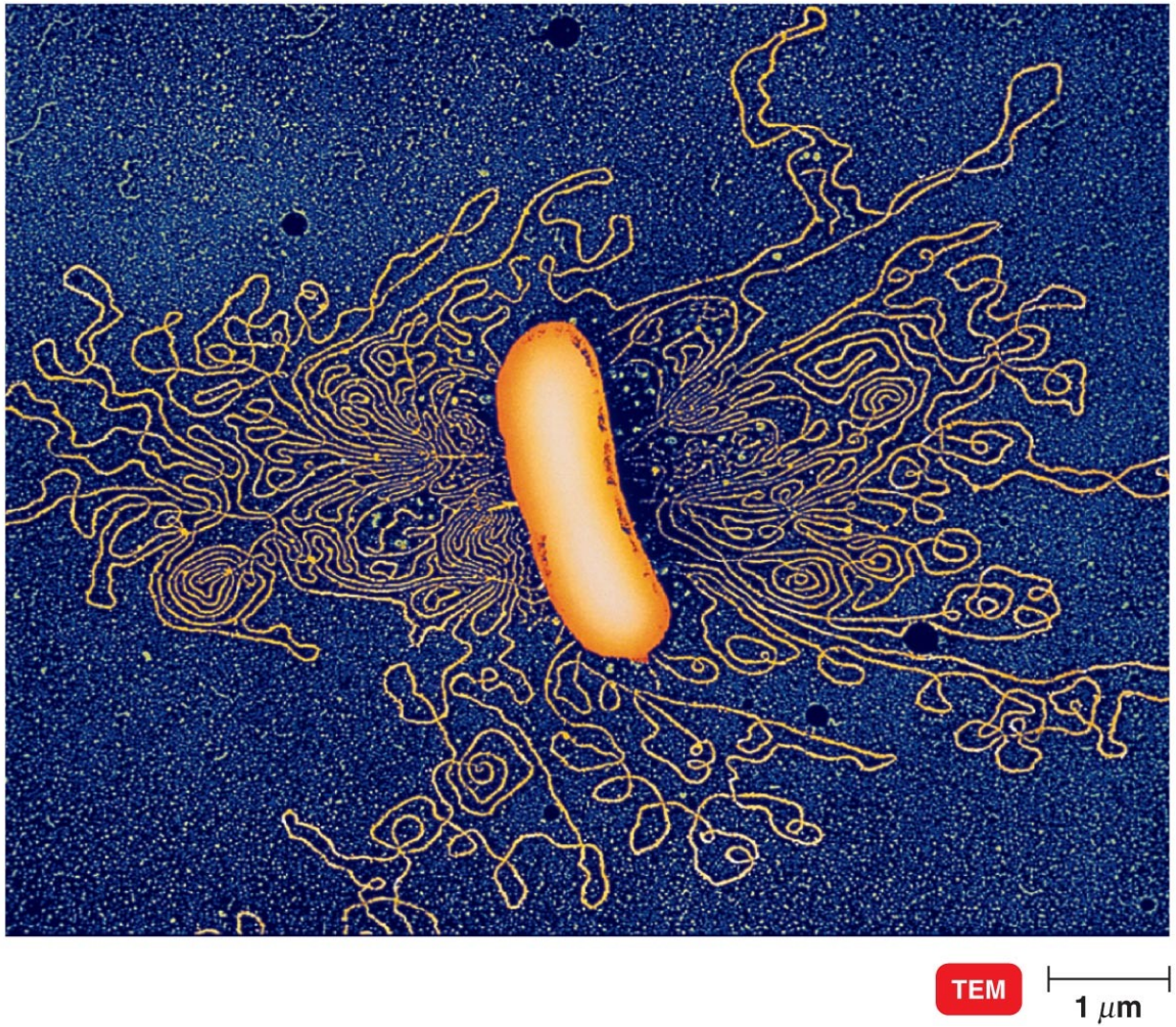
Genotype and Phenotype

- **Genotype:** the genetic makeup of an organism
- **Phenotype:** expression of the genes

DNA and Chromosomes

- Bacteria usually have a single circular chromosome made of DNA and associated proteins
- **Short tandem repeats (STRs):** repeating sequences of noncoding DNA

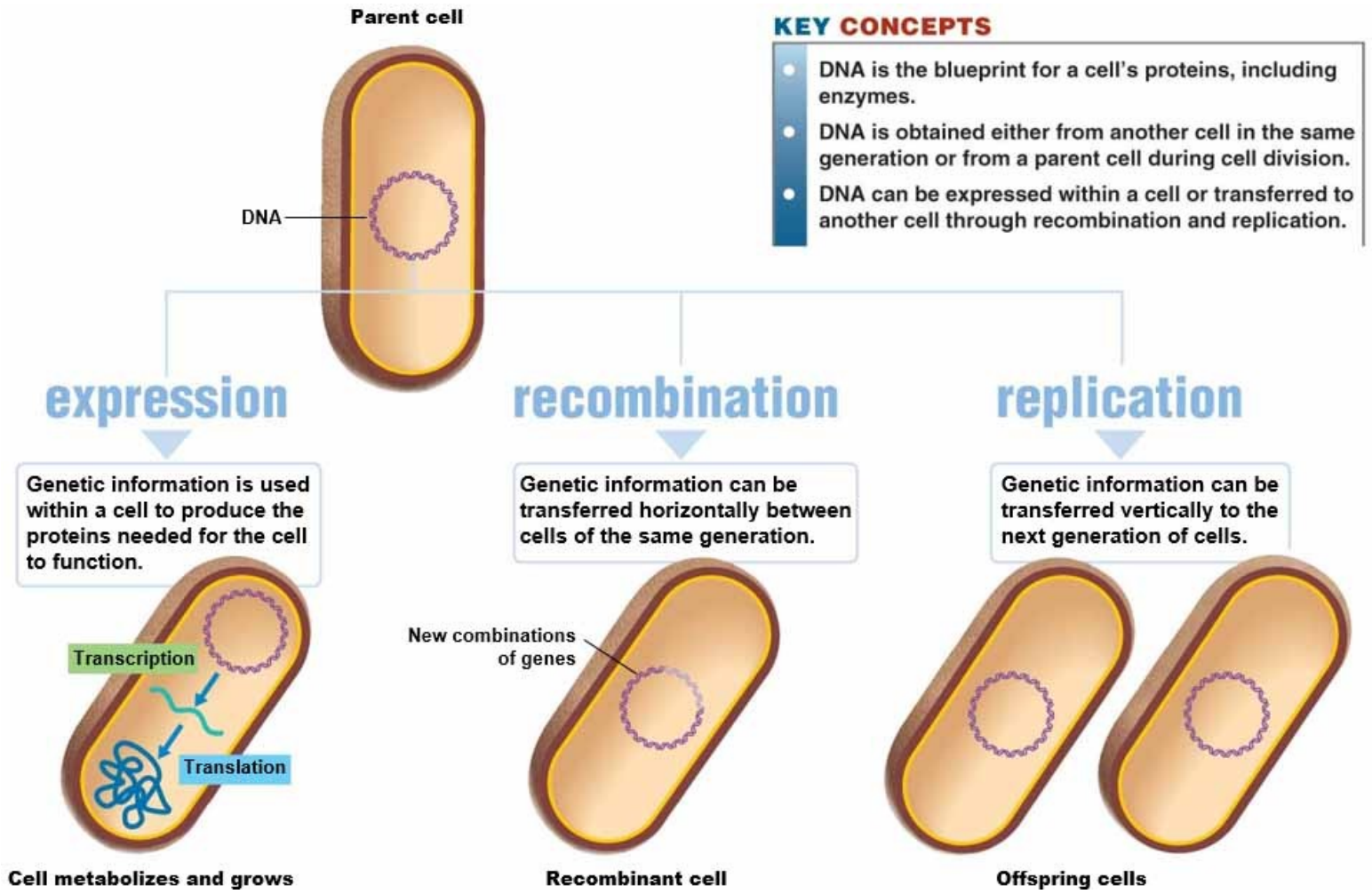
Figure 8.1 a Prokaryotic Chromosome



The Flow of Genetic Information (1 of 2)

- **Vertical gene transfer:** flow of genetic information from one generation to the next

Figure 8.2 The Flow of Genetic Information



Check Your Understanding-1

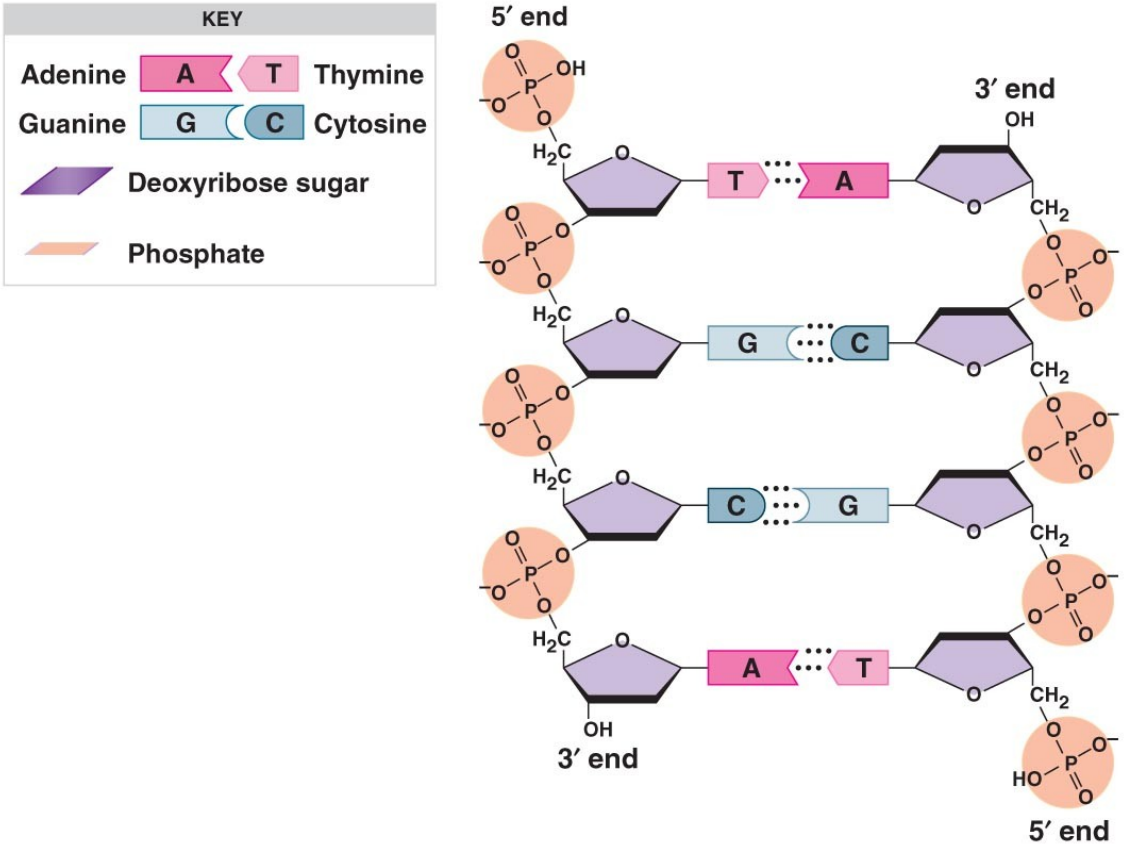
Check Your Understanding

- ✓ Give a clinical application of genomics.
  8-1
- ✓ Why is the base pairing in DNA important?
  8-2

DNA Replication (1 of 8)

- DNA forms a double helix
  - "Backbone" consists of deoxyribose-phosphate
  - Two strands of nucleotides are held together by hydrogen bonds between A-T and C-G
  - Strands are antiparallel
- Order of the nitrogen-containing bases forms the genetic instructions of the organism

Figure 8.3b DNA Replication

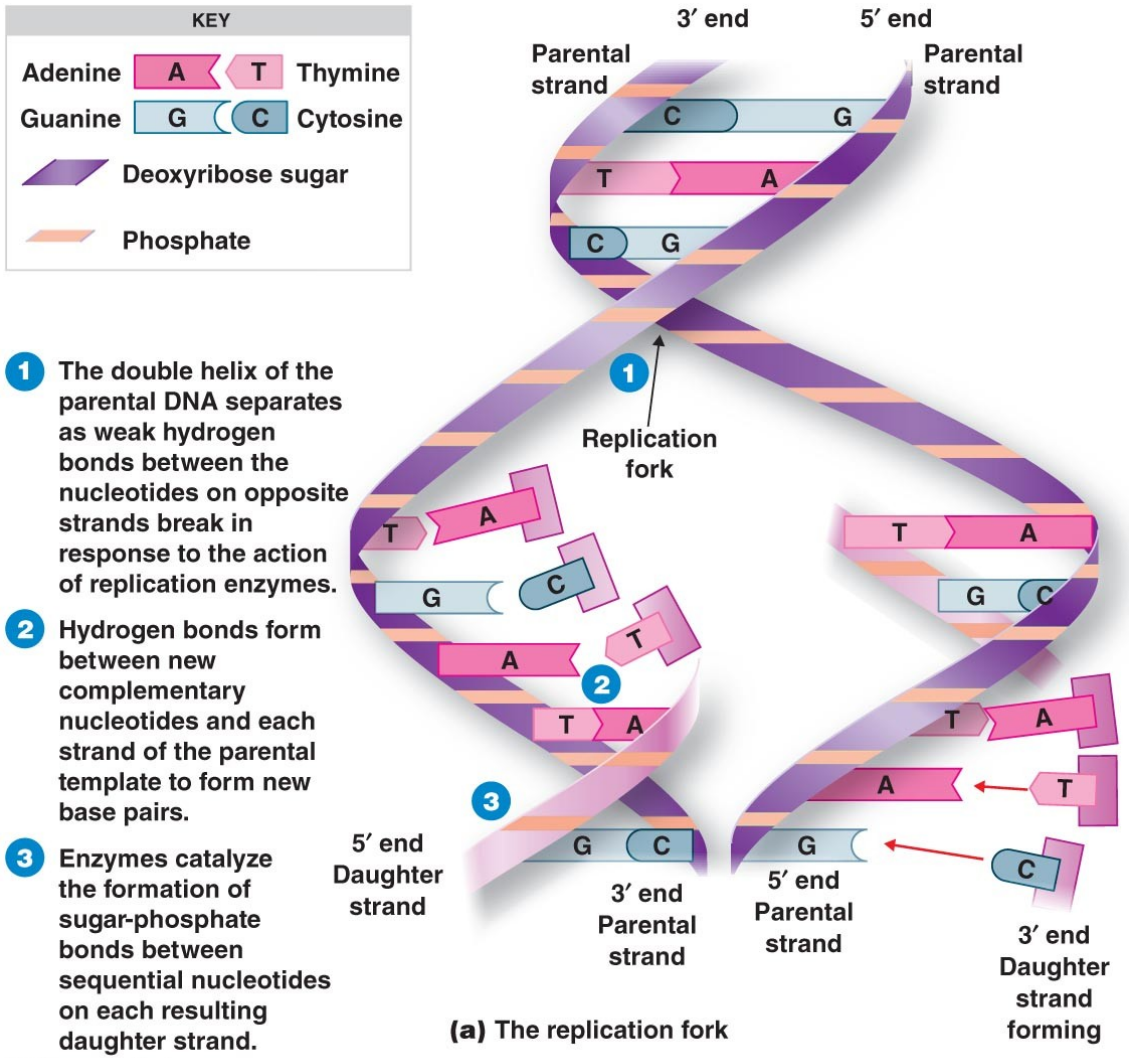


(b) The two strands of DNA are antiparallel. The sugar-phosphate backbone of one strand is upside down relative to the backbone of the other strand. Turn the book upside down to demonstrate this.

DNA Replication (2 of 8)

- One strand serves as a template for the production of a second strand
- Topoisomerase and gyrase relax the strands
- Helicase separates the strands
- A replication fork is created

Figure 8.3a DNA Replication



DNA Replication (3 of 8)

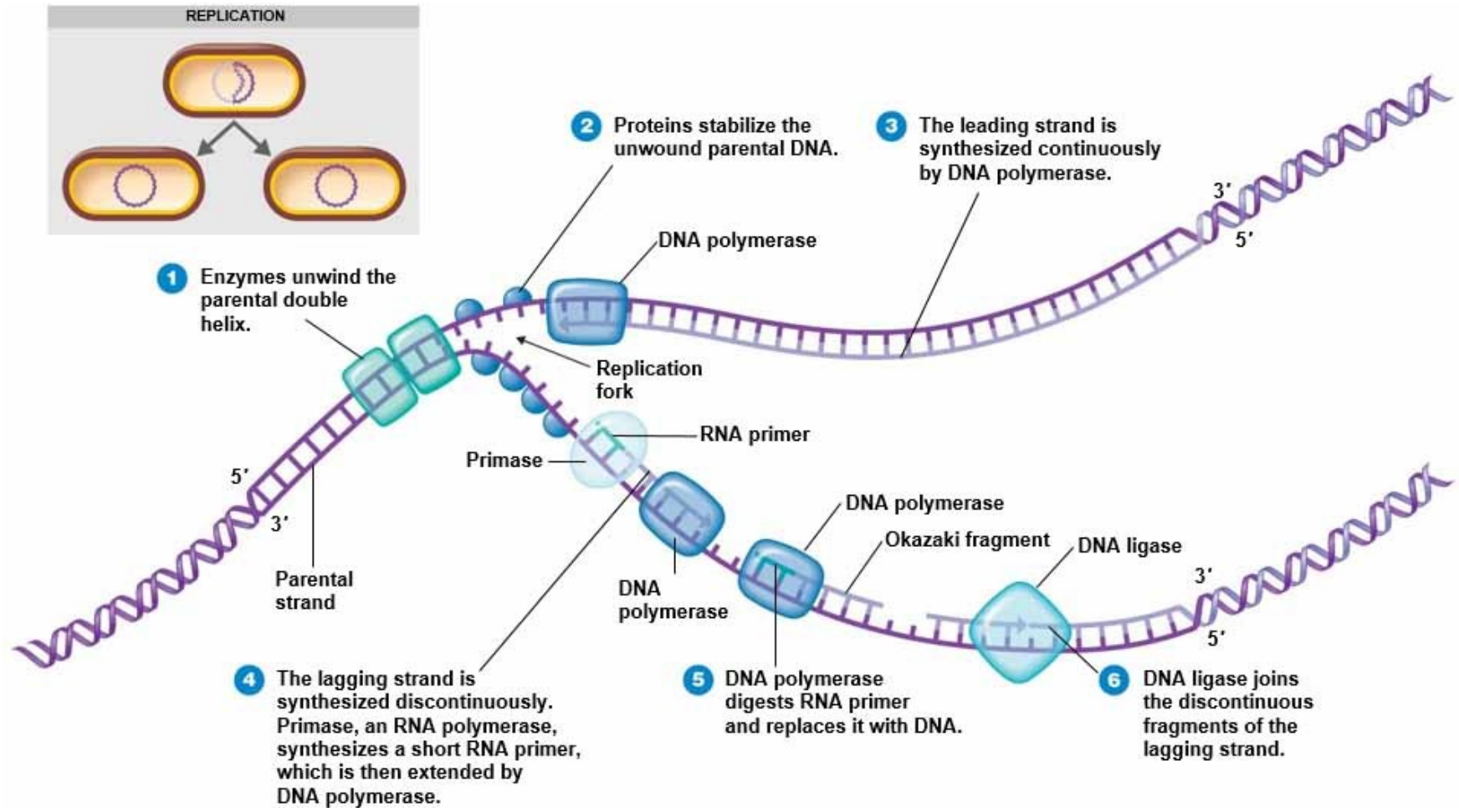
- **DNA polymerase** adds nucleotides to the growing DNA strand
  - In the 5' → 3' direction
  - Initiated by an RNA primer
  - Leading strand is synthesized continuously
  - Lagging strand is synthesized discontinuously, creating Okazaki fragments
  - DNA polymerase removes RNA primers; Okazaki fragments are joined by the DNA polymerase and DNA ligase

Table 8.1 Important Enzymes in DNA Replication, Expression, and Repair

Table 8.1 **Important Enzymes in DNA Replication, Expression, and Repair**

and Cyclase	Relaxes supercoiling ahead of the replication fork
DNA Ligase	Makes covalent bonds to join DNA strands; Okazaki fragments, and new segments in excision repair
DNA Polymerases	Synthesizes DNA; proofreads and repairs DNA
Endonucleases	Cut DNA backbone in a strand of DNA; facilitate repair and insertions
Exonucleases	Cut DNA from an exposed end of DNA; facilitate repair
Helicase	Unwinds double-stranded DNA
Methylase	Adds methyl group to selected bases in newly made DNA
Photolyase	Uses visible light energy to separate UV-induced pyrimidine dimers
Primase	An RNA polymerase that makes RNA primers from a DNA template
Ribozyme	RNA enzyme that removes introns and splices exons together
RNA Polymerase	Copies RNA from a DNA template
snRNP	RNA-protein complex that removes introns and splices exons together
Topoisomerase	Relaxes supercoiling ahead of the replication fork; separates DNA circles at the end of DNA replication
Transposase	Cuts DNA backbone, leaving single-stranded “sticky ends”

Figure 8.5 a Summary of Events at the DNA Replication Fork



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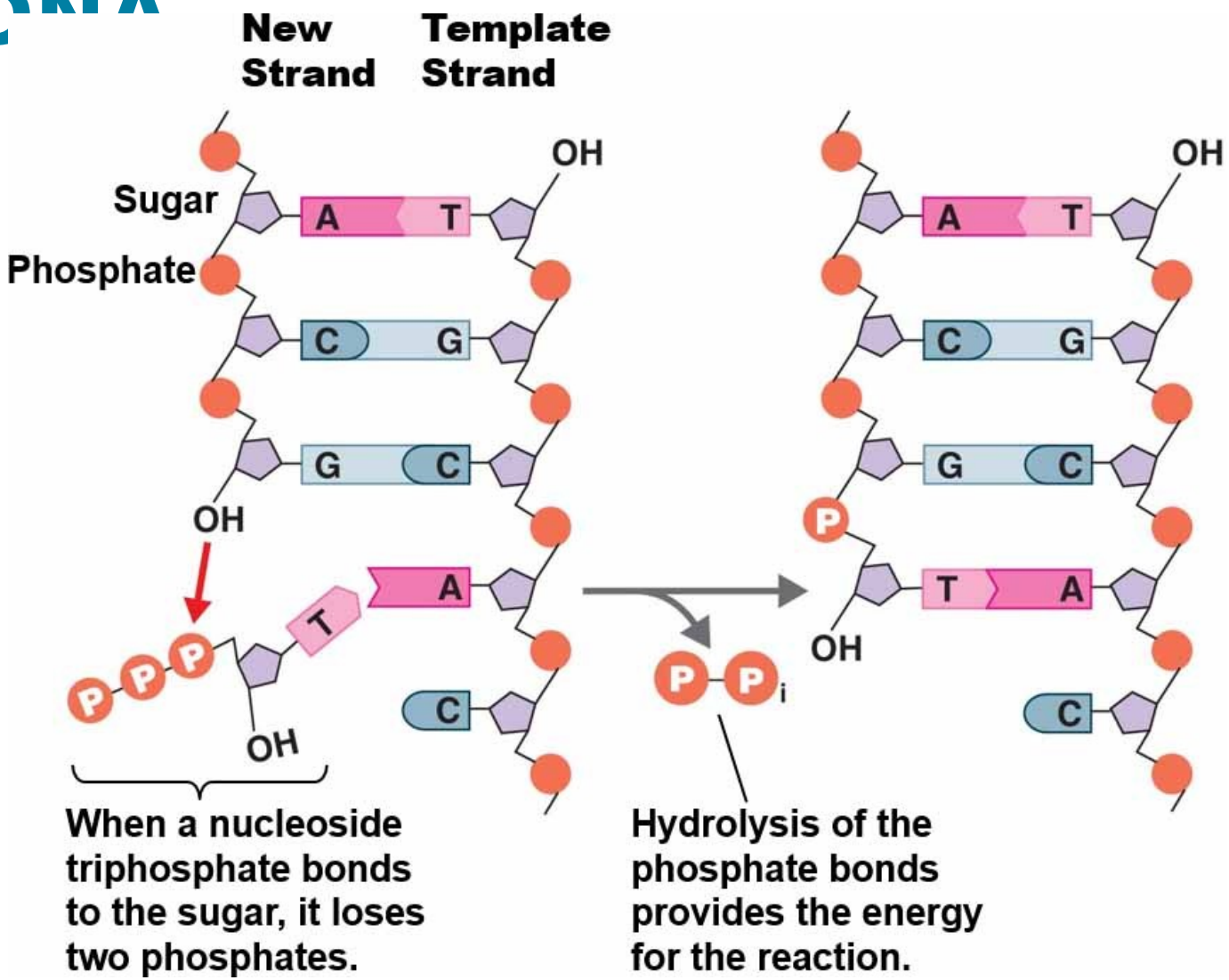
DNA Replication (4 of 8)

- Energy for replication is supplied by nucleotides
- Hydrolysis of two phosphate groups on ATP provides energy

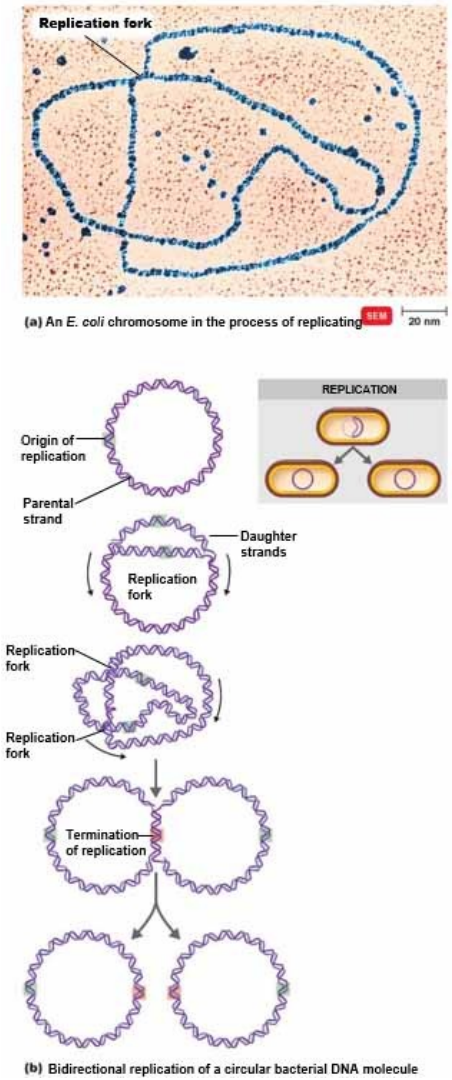
Figure 8.4 Adding a Nucleotide to DNA



DNA Replication (5 of 8)

- Most bacterial DNA replication is bidirectional
- Each offspring cell receives one copy of the DNA molecule
- Replication is highly accurate due to the proofreading capability of DNA polymerase

Figure 8.6 Replication of Bacterial DNA



(a) An *E. coli* chromosome in the process of replicating

(b) Bidirectional replication of a circular bacterial DNA molecule

DNA Replication (6 of 8)

PLAY **Animation: DNA Replication: Overview**

DNA Replication (7 of 8)

PLAY **Animation: DNA Replication: Forming the Replication Fork**

DNA Replication (8 of 8)

PLAY **Animation: DNA Replication: Proteins**

Check Your Understanding-2

Check Your Understanding

- Describe DNA replication, including the functions of DNA gyrase, DNA ligase, and DNA polymerase.
  8-3

RNA and Protein Synthesis (1 of 2)

- Ribonucleic acid
  - Single-stranded nucleotide
  - 5-carbon ribose sugar
  - Contains uracil (U) instead of thymine (T)

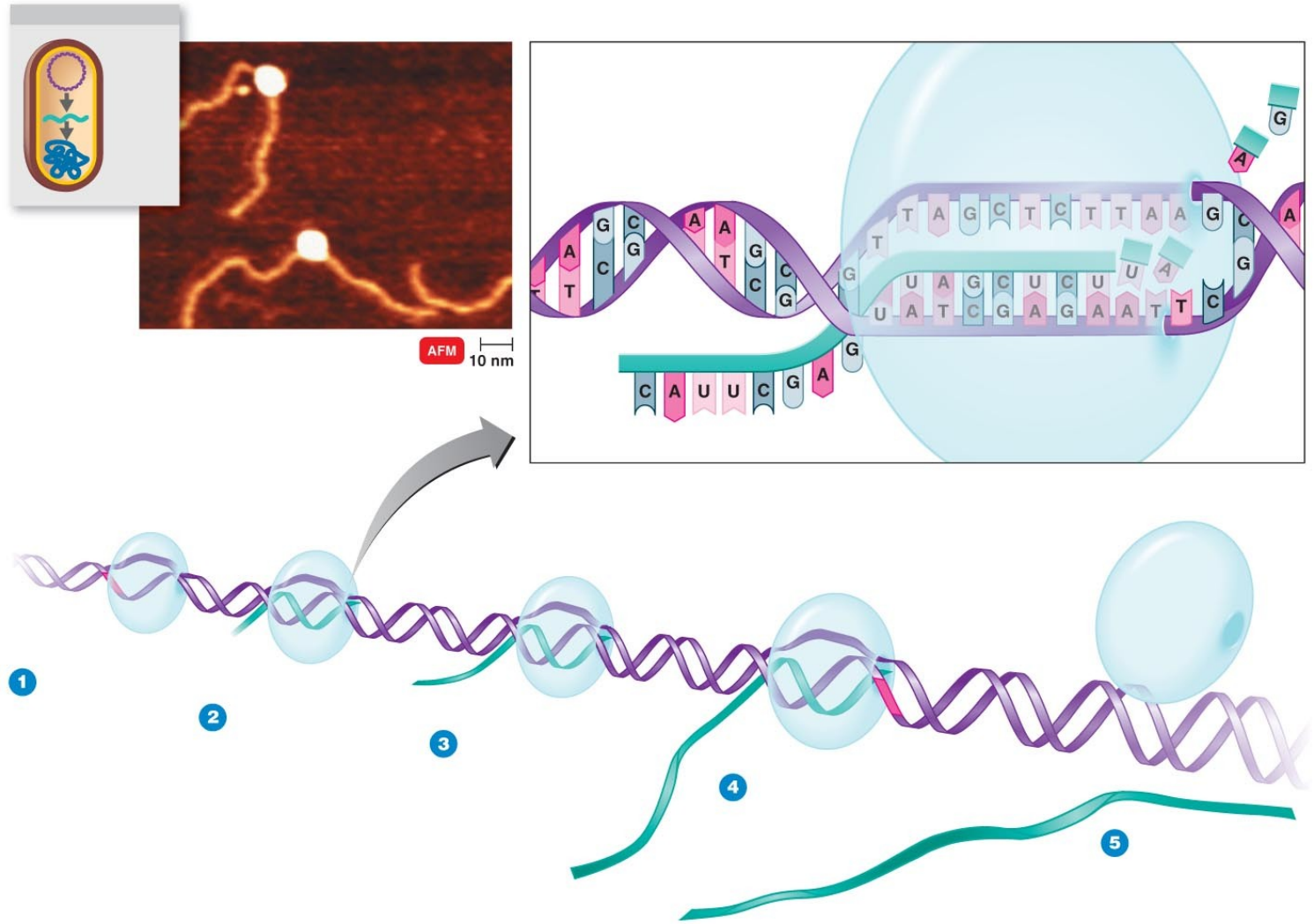
RNA and Protein Synthesis (2 of 2)

- **Ribosomal RNA (rRNA):** integral part of ribosomes
- **Transfer RNA (tRNA):** transports amino acids during protein synthesis
- **Messenger RNA (mRNA):** carries coded information from DNA to ribosomes

Transcription in Prokaryotes (1 of 3)

- Synthesis of a complementary mRNA strand from a DNA template
- Transcription begins when RNA polymerase binds to the **promoter** sequence on DNA
- Transcription proceeds in the 5' → 3' direction; only one of the two DNA strands is transcribed
- Transcription stops when it reaches the **terminator** sequence on DNA

Figure 8.7 The Process of Transcription



Transcription in Prokaryotes (2 of 3)

PLAY **Animation: Transcription: Overview**

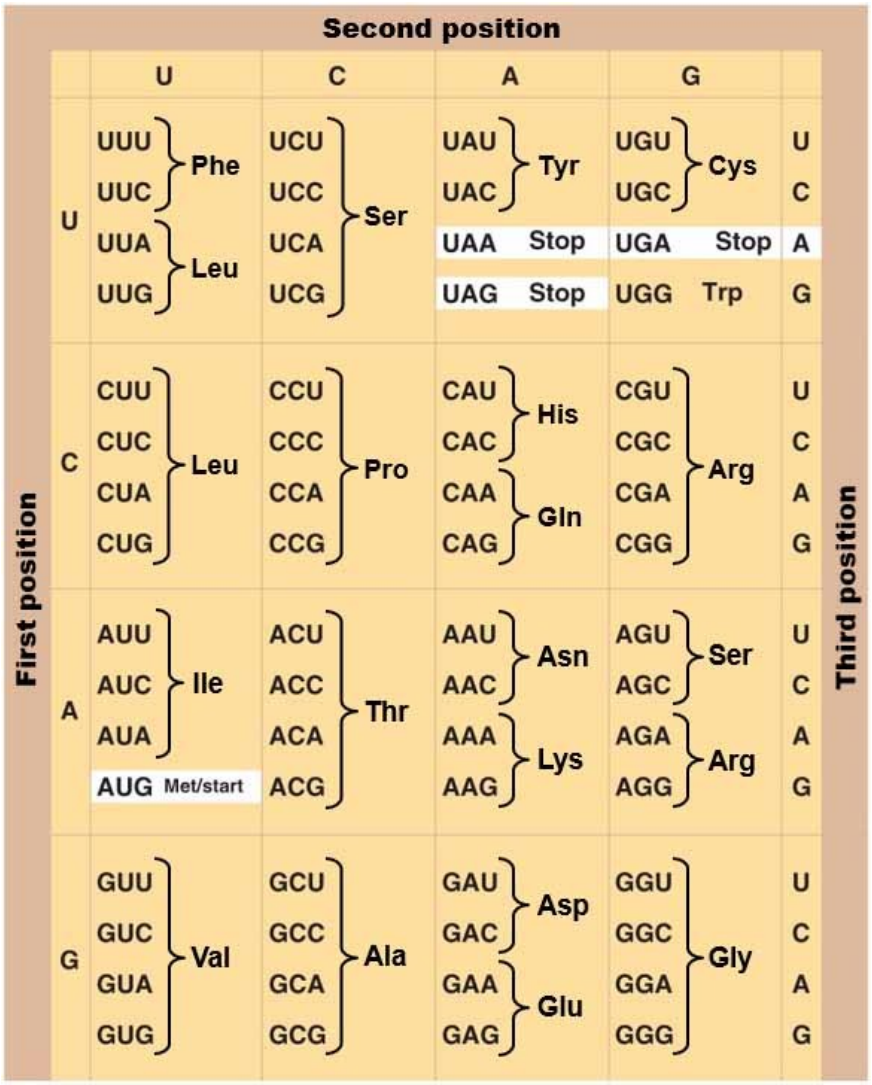
Transcription in Prokaryotes (3 of 3)

PLAY **Animation: Transcription: The Process**

Translation (1 of 4)

- mRNA is translated into the "language" of proteins
- **Codons** are groups of three mRNA nucleotides that code for a particular amino acid
- 61 **sense codons** encode the 20 amino acids
- The genetic code involves **degeneracy,** meaning each amino acid is coded by several codons

Figure 8.8 The Genetic Code



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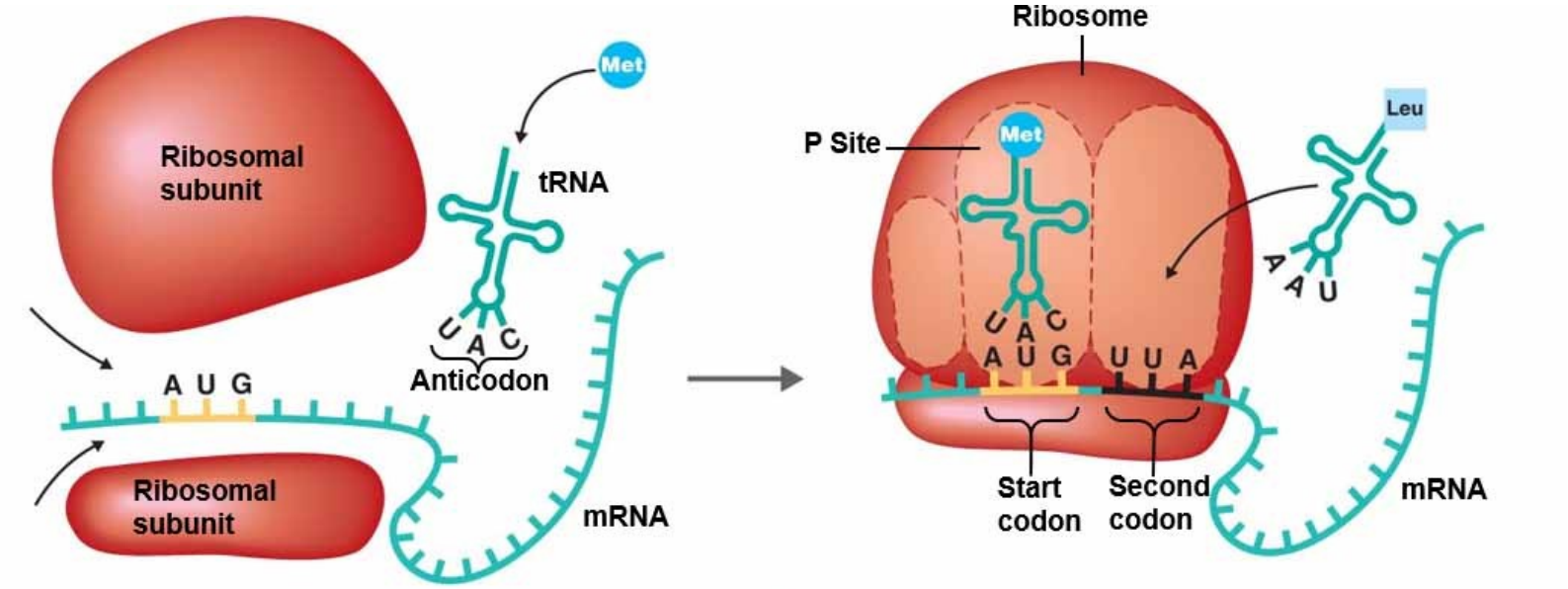
Translation (2 of 4)

- Translation of mRNA begins at the start codon: AUG
- Translation ends at nonsense codons: UAA, UAG, UGA
- Codons of mRNA are "read" sequentially

Translation (3 of 4)

- tRNA molecules transport the required amino acids to the ribosome
- tRNA molecules also have an **anticodon** that base-pairs with the codon
- Amino acids are joined by peptide bonds

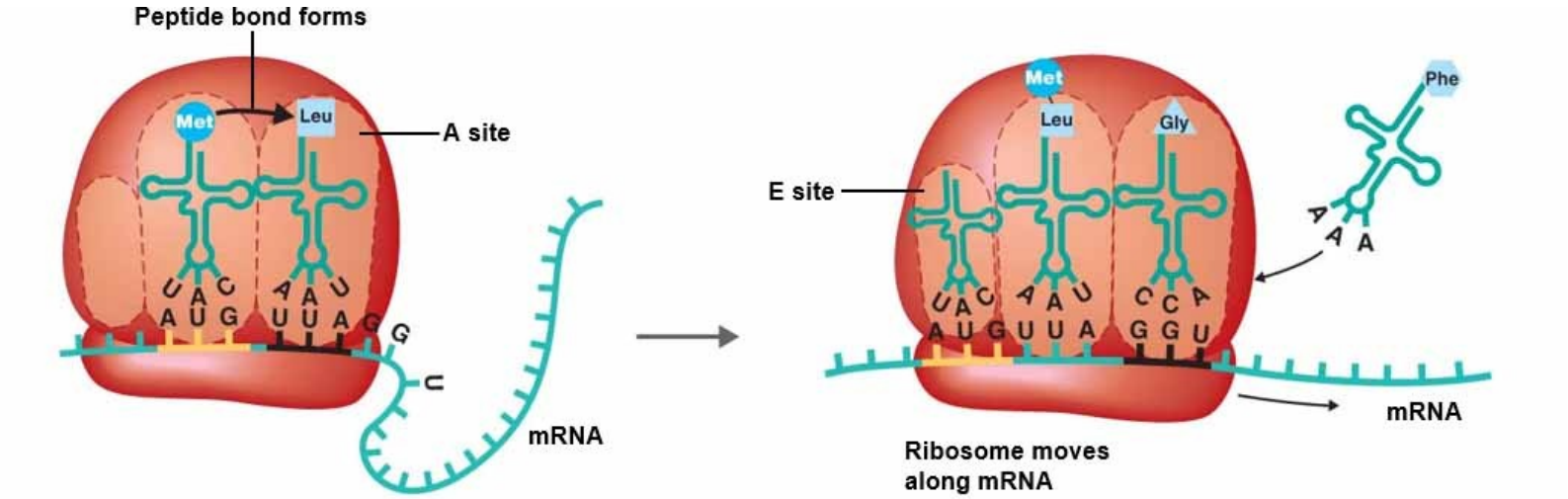
Figure 8.9 The Process of Translation (1 of 4)



1 Components needed to begin translation come together.

2 On the assembled ribosome, a tRNA carrying the first amino acid is paired with the start codon on the mRNA. The place where this first tRNA sits is called the P site. A tRNA carrying the second amino acid approaches.

Figure 8.9 The Process of Translation (2 of 4)



3 The second codon of the mRNA pairs with a tRNA carrying the second amino acid at the A site. The first amino acid joins to the second by a peptide bond. This attaches the polypeptide to the tRNA in the P site.

4 The ribosome moves along the mRNA until the second tRNA is in the P site. The next codon to be translated is brought into the A site. The first tRNA now occupies the E site.

Figure 8.9 The Process of Translation (3 of 4)

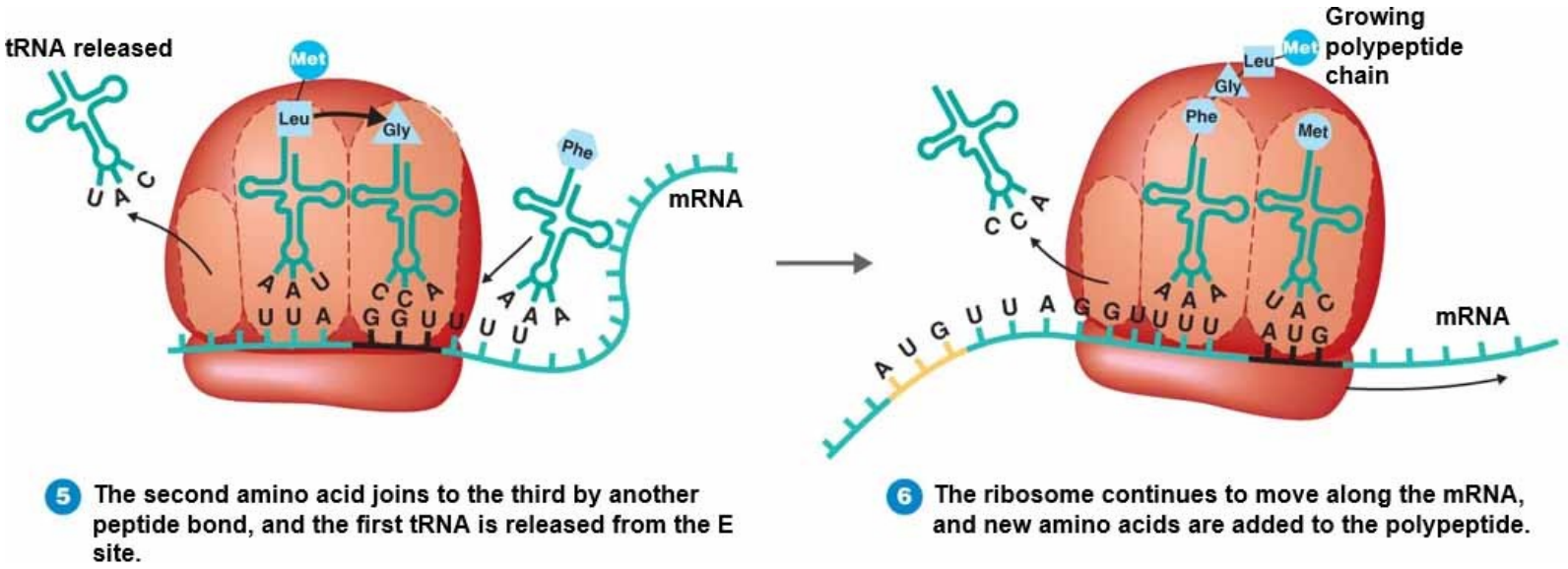
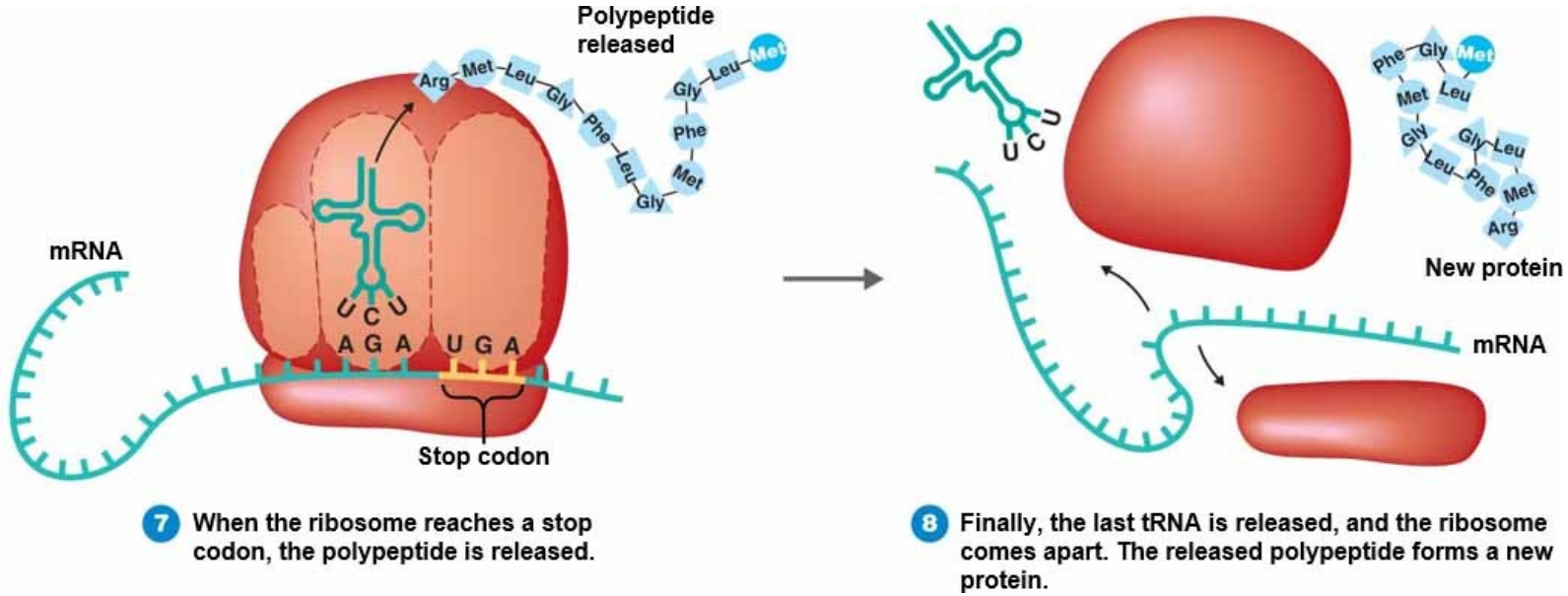


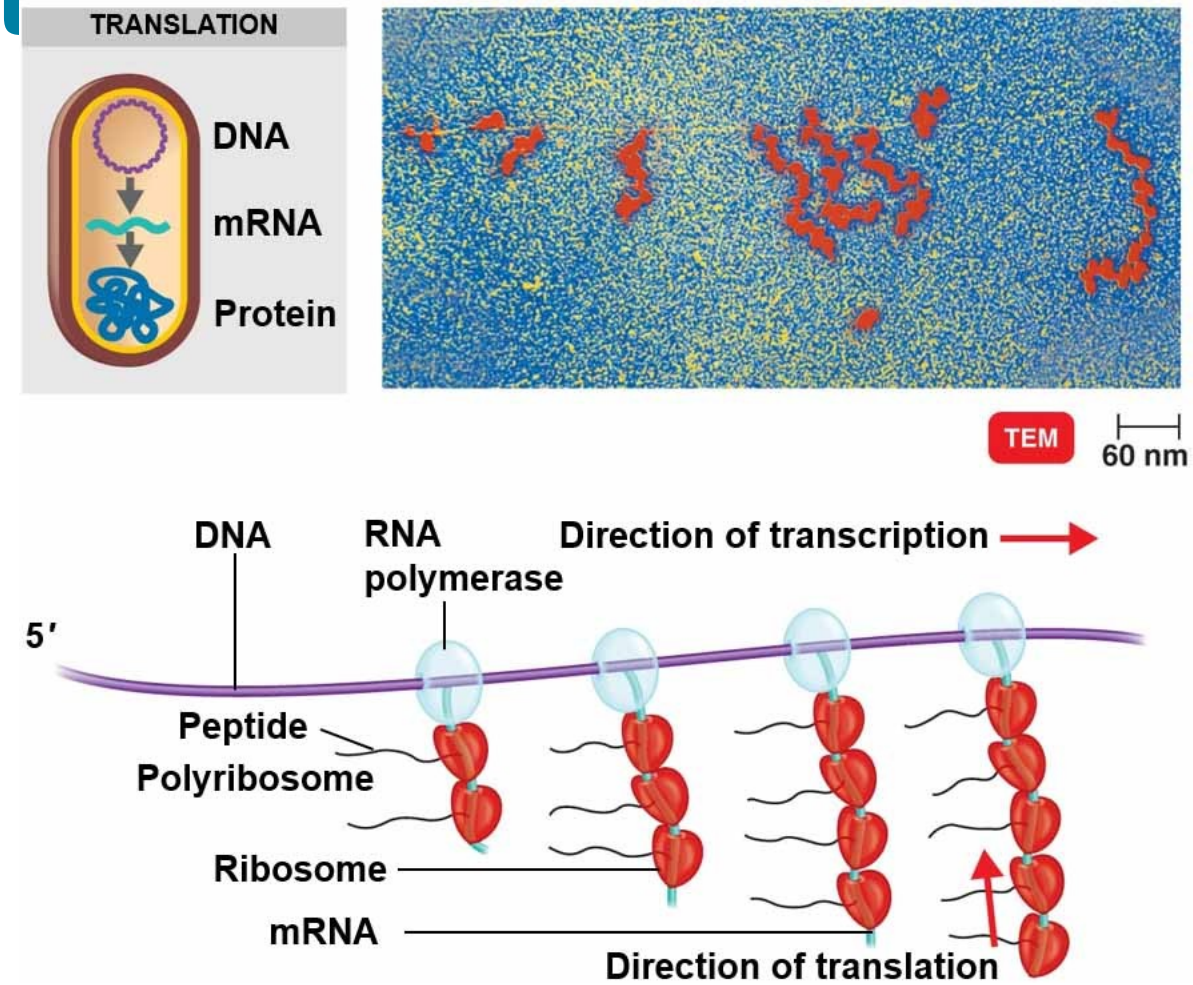
Figure 8.9 The Process of Translation (4 of 4)



Translation (4 of 4)

- In bacteria, translation can begin before transcription is complete

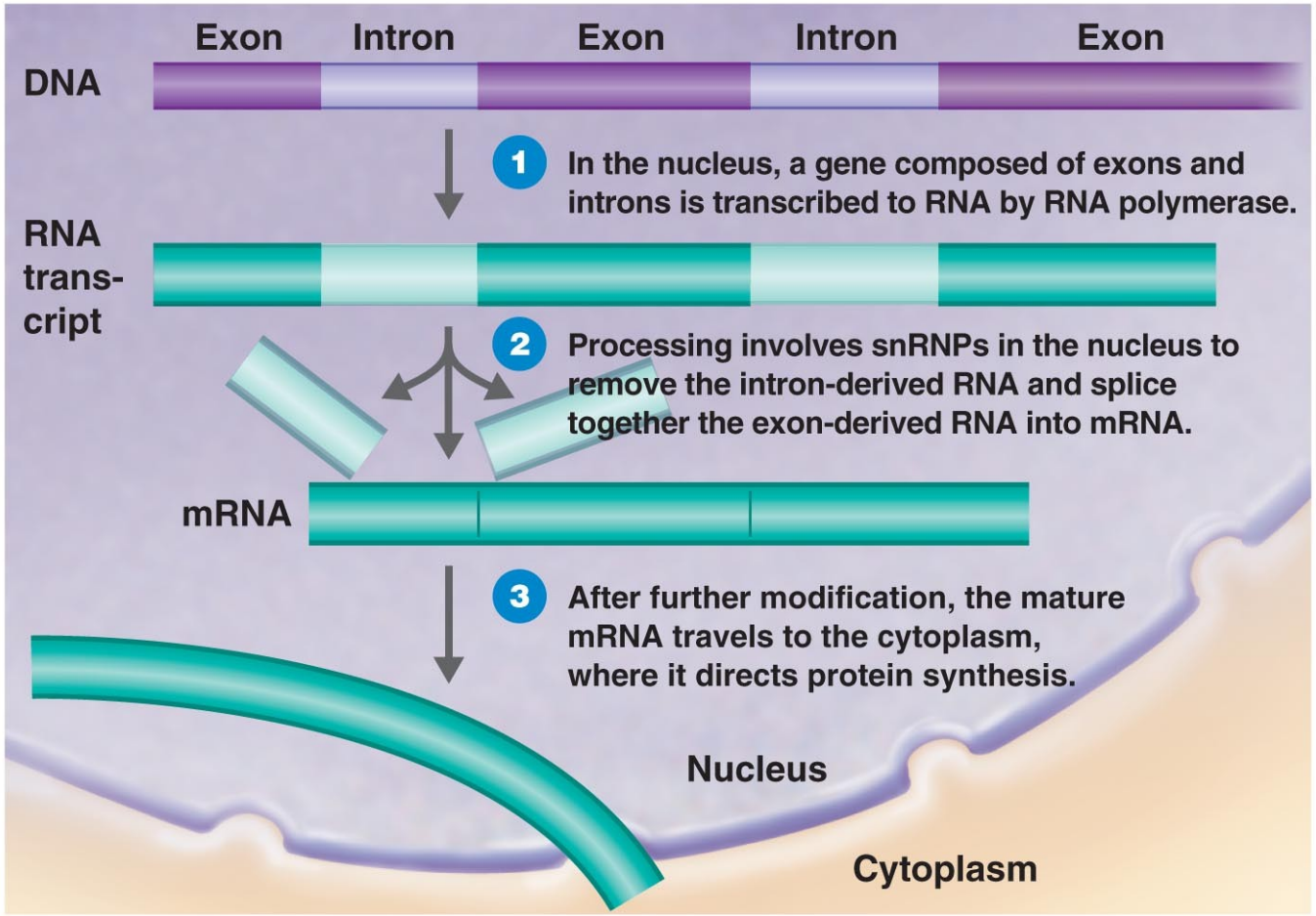
Figure 8.10 Simultaneous Transcription and Translation in Bacteria



Transcription in Eukaryotes (1 of 4)

- In eukaryotes, transcription occurs in the nucleus, whereas translation occurs in the cytoplasm
- **Exons** are regions of DNA that code for proteins
- **Introns** are regions of DNA that do not code for proteins
- **Small nuclear ribonucleoproteins (snRNPs)** remove introns and splice exons together

Figure 8.11 RNA Processing in Eukaryotic Cells



Transcription in Eukaryotes (2 of 4)

PLAY **Animation: Transcription: Overview**

Transcription in Eukaryotes (3 of 4)

PLAY **Animation: Transcription: The Genetic Code**

Transcription in Eukaryotes (4 of 4)

PLAY **Animation: Transcription: The Process**

Check Your Understanding-3

Check Your Understanding

- What is the role of the promoter, terminator, and mRNA in transcription?
  8-4
- How does mRNA production in eukaryotes differ from the process in prokaryotes?
  8-5

The Regulation of Bacterial Gene Expression (1 of 2)

Learning Objectives

8-6 Define **operon.**

8-7 Explain pre-transcriptional regulation of gene expression in bacteria.

8-8 Explain post-transcriptional regulation of gene expression.

The Regulation of Bacterial Gene Expression (2 of 2)

- Constitutive genes are expressed at a fixed rate
- Other genes are expressed only as needed
  - Inducible genes
  - Repressible genes
  - **Catabolite** repression

Pre-transcriptional Control (1 of 3)

- **Repression** inhibits gene expression and decreases enzyme synthesis
  - Mediated by **repressors,** proteins that block transcription
  - Default position of a repressible gene is **on**
- **Induction** turns on gene expression
  - Initiated by an **inducer**
  - Default position of an inducible gene is **off**

Pre-transcriptional Control (2 of 3)

PLAY **Animation: Operons: Induction**

Pre-transcriptional Control (3 of 3)

PLAY **Animation: Operons: Repression**

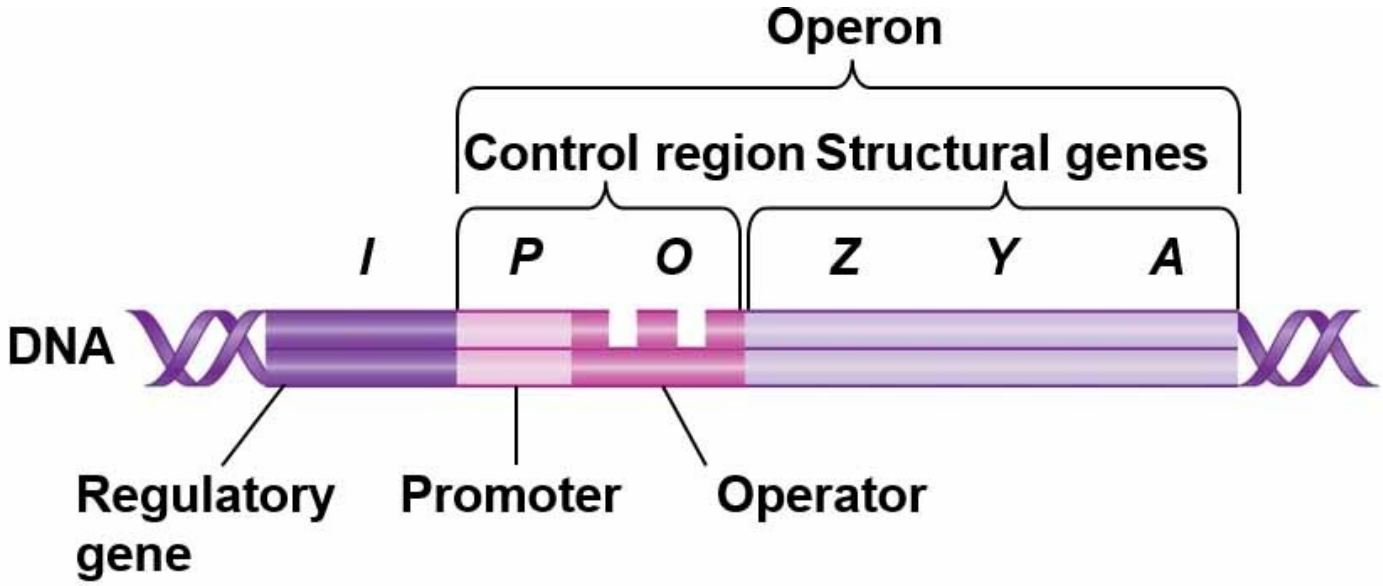
The Operon Model of Gene Expression (1 of 4)

- Promoter: segment of DNA where RNA polymerase initiates transcription of structural genes
- **Operator**: segment of DNA that controls transcription of structural genes
- **Operon**: set of operator and promoter sites and the structural genes they control

The Operon Model of Gene Expression (2 of 4)

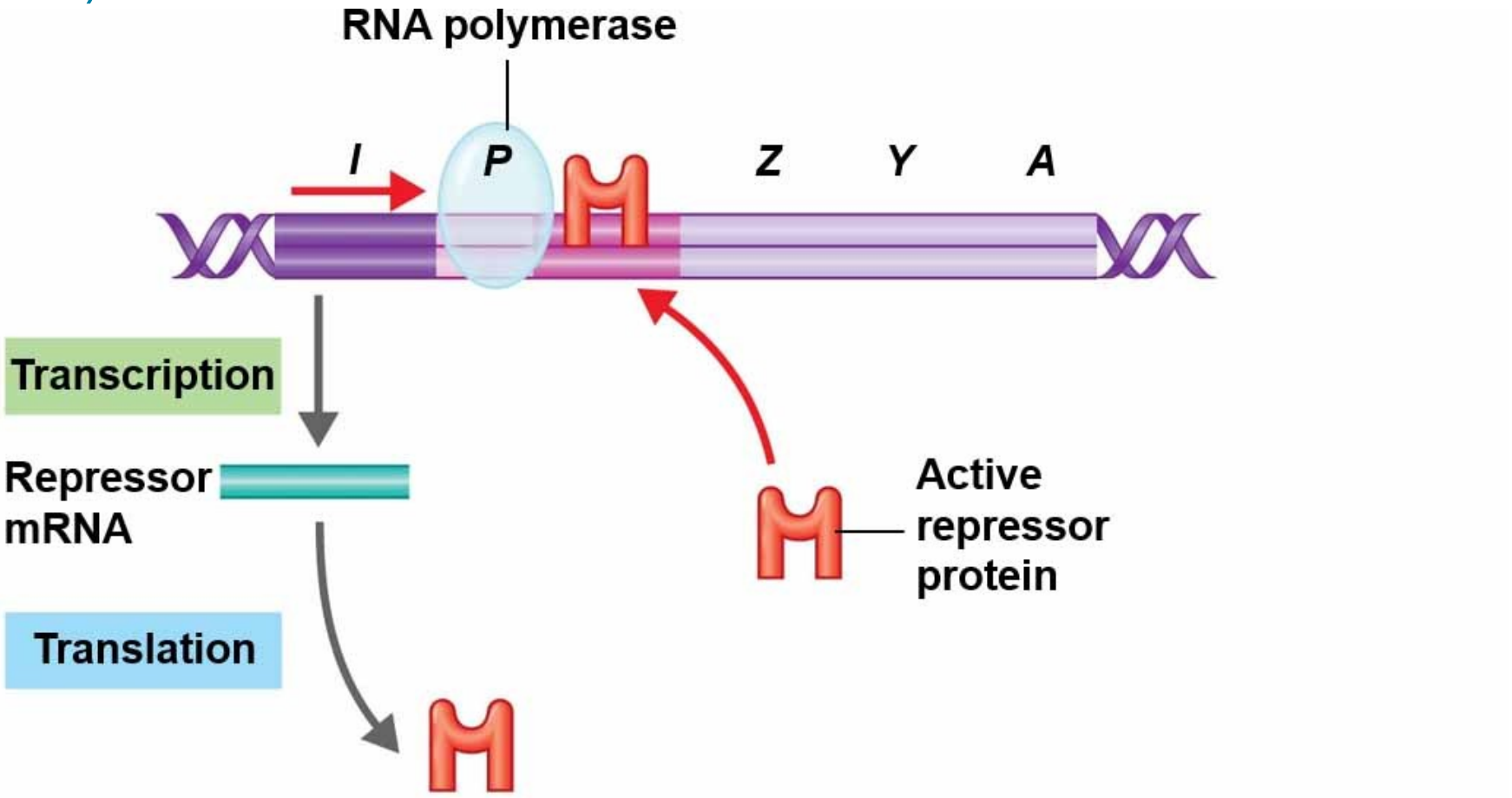
- In an **inducible operon,** structural genes are not transcribed unless an inducer is present
  - In the absence of lactose, the repressor binds to the operator, preventing transcription
  - In the presence of lactose, lactose (inducer) binds to the repressor; the repressor cannot bind to the operator and transcription occurs

Figure 8.12 An Inducible Operon (1 of 3)



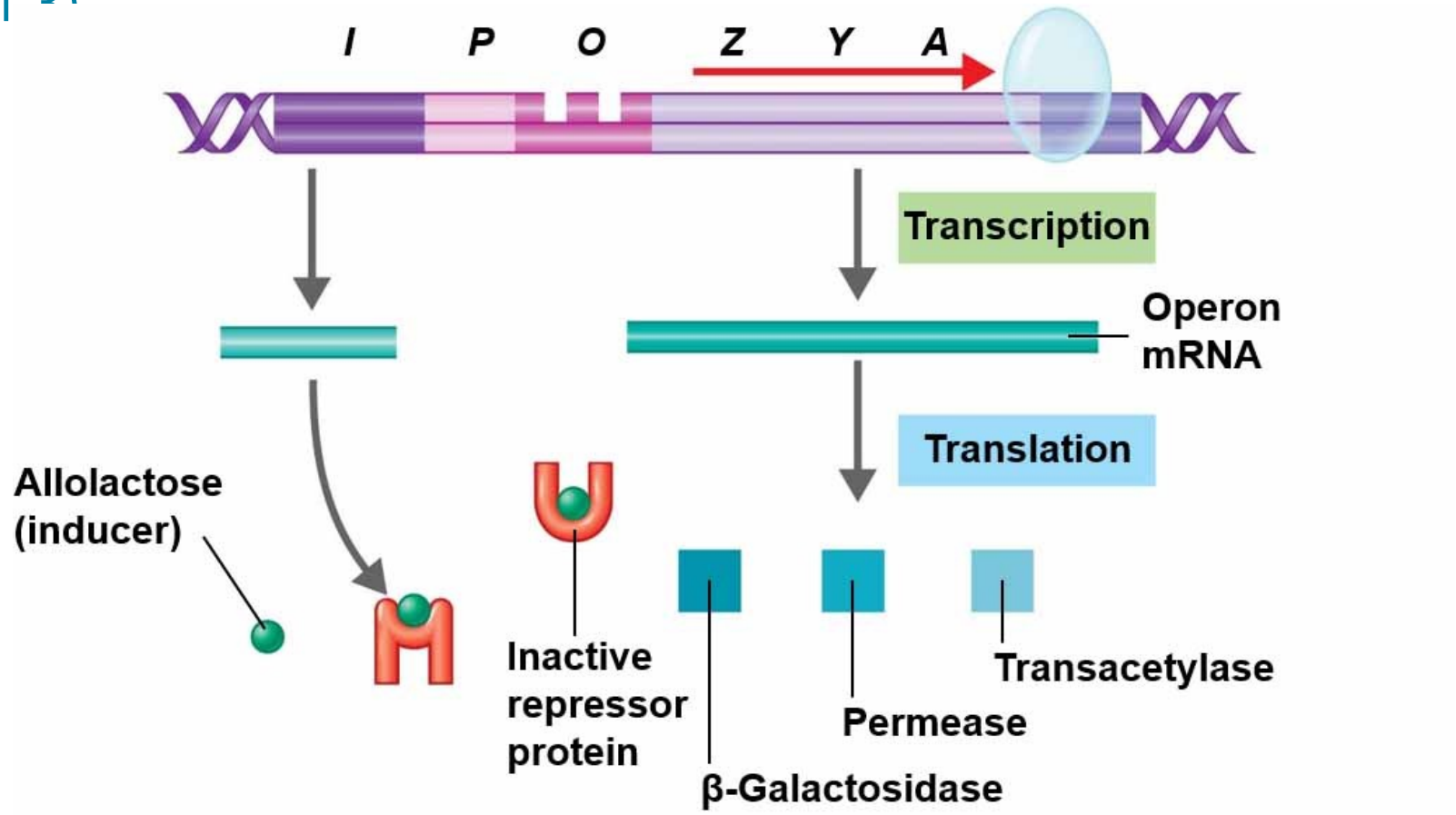
1 **Structure of the operon.** The operon consists of the promoter (*P*) and operator (O) sites and structural genes that code for the protein. The operon is regulated by the product of the regulatory gene (*I*)

Figure 8.12 An Inducible Operon (2 of 3)



2 **Repressor active, operon off.** The repressor protein binds with the operator, preventing transcription from the operon.

Figure 8.12 An Inducible Operon (3 of 3)



3 **Repressor inactive, operon on.** When the inducer allolactose binds to the repressor protein, the inactivated repressor can no longer block transcription. The structural genes are transcribed, ultimately resulting in the production of the enzymes needed for lactose catabolism.

The Operon Model of Gene Expression (3 of 4)

- In **repressible operons,** structural genes are transcribed until they are turned off
  - Excess tryptophan is a **corepressor** that binds and activates the repressor to bind to the operator, stopping tryptophan synthesis

Figure 8.13 A Repressible Operon (1 of 3)

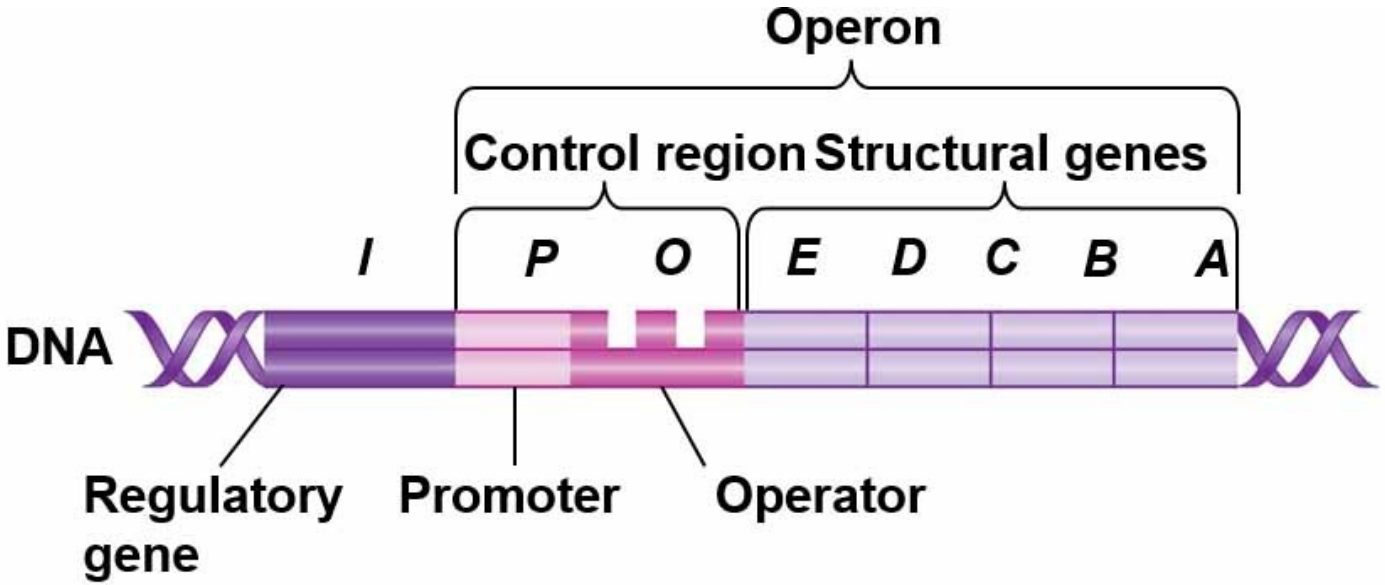


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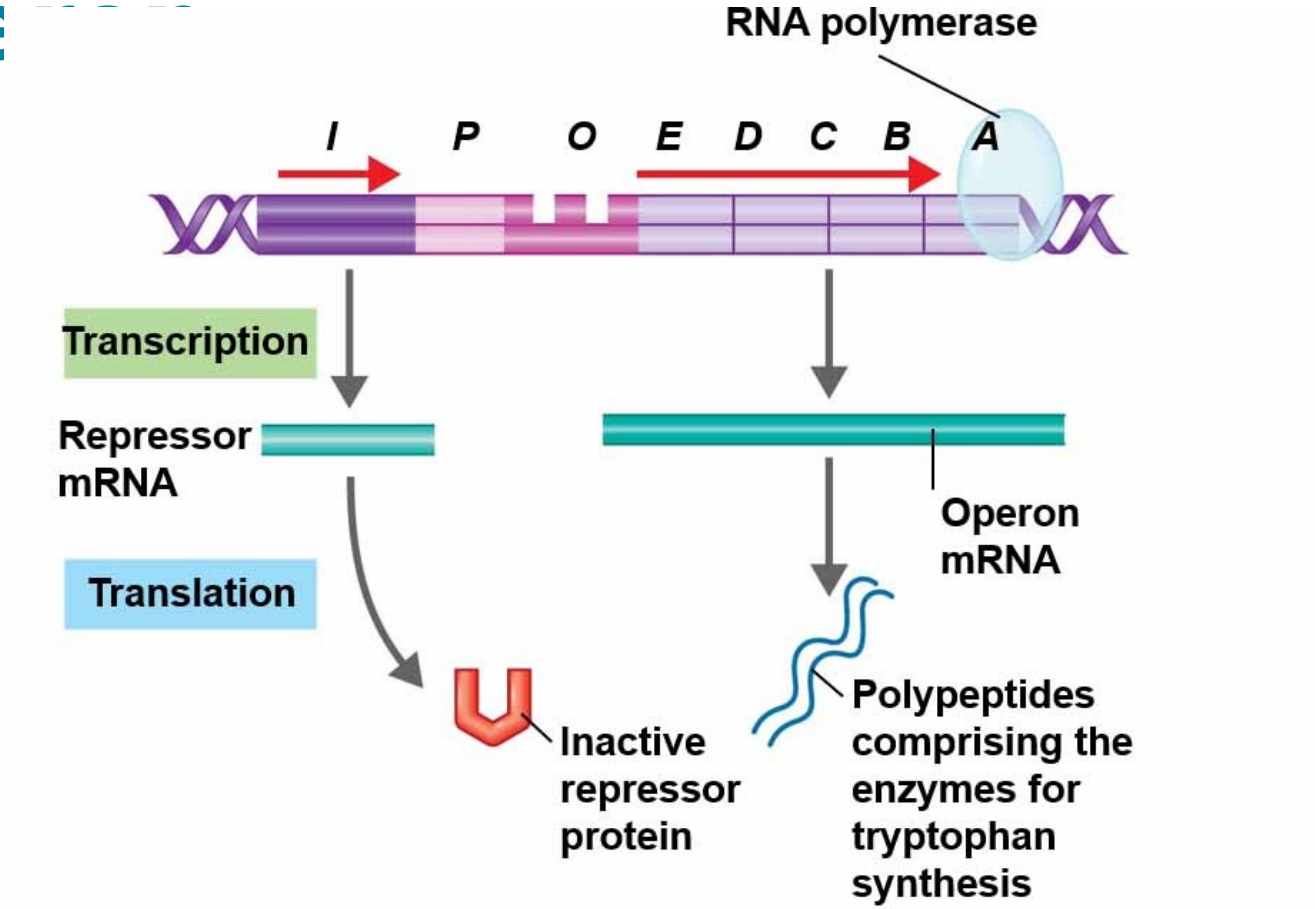
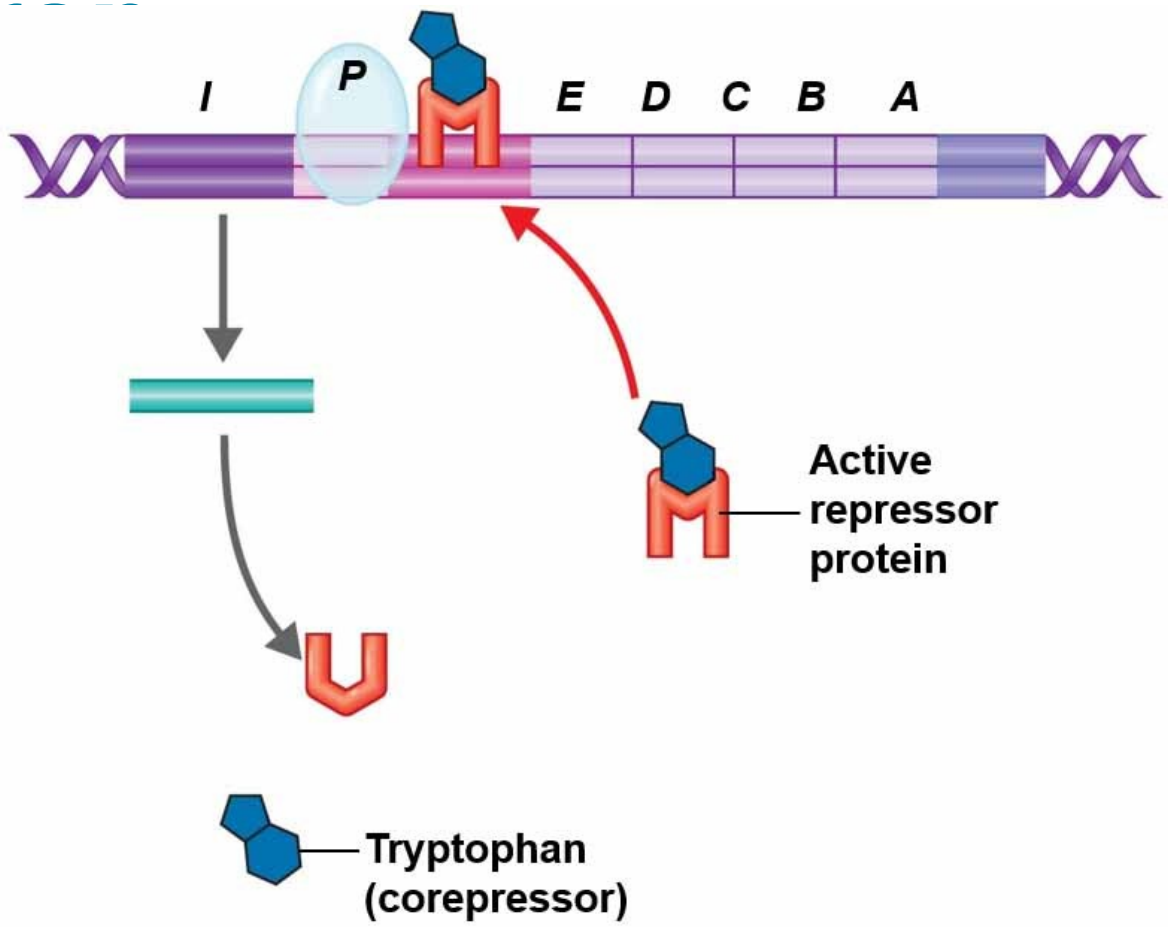
Figure 8.13 A Repressible Ope



2 **Repressor inactive, operon on.** The repressor is inactive, and transcription and translation proceed, leading to the synthesis of tryptophan.

Figure 8.13 A Repressible Operon



3 **Repressor active, operon off.** When the corepressor tryptophan binds to the repressor protein, the activated repressor binds with the operator, preventing transcription from the operon.

The Operon Model of Gene Expression (4 of 4)

PLAY **Animation: Operons: Overview**

Check Your Understanding-4

Check Your Understanding

- ✓ Use the following metabolic pathway to answer the questions that follow it.
  8-6

$$\text{Substrate } A \xrightarrow{\text{enzyme } a} \text{Intermediate } B \xrightarrow{\text{enzyme } b} \text{End-product } C$$

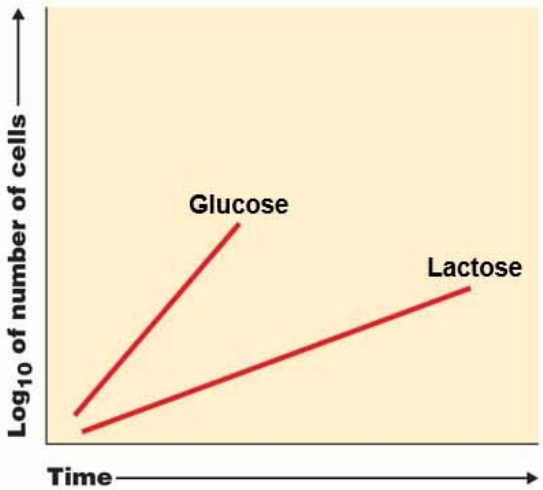
a. If enzyme *a* is inducible and is not being synthesized at present, a (1) _____ protein must be bound tightly to the (2) _____ site. When the inducer is present, it will bind to the (3) _____ so that (4) _____ can occur.

b. If enzyme *a* is repressible, end-product *C*, called a (1) _____, causes the (2) _____ to bind to the (3) _____. What causes derepression?

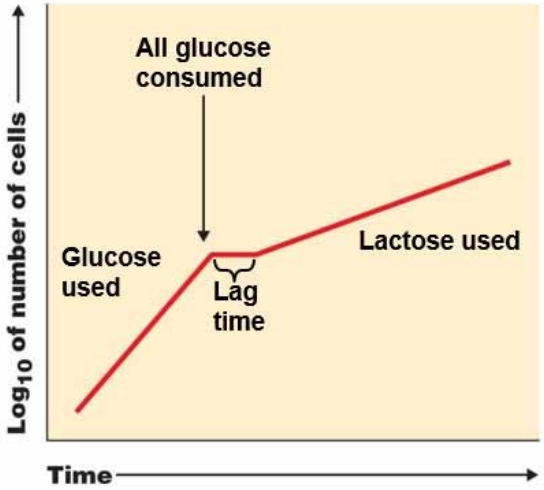
Positive Regulation

- **Catabolite repression** inhibits cells from using carbon sources other than glucose
- **Cyclic AMP (cAMP)** builds up in a cell when glucose is not available
- cAMP binds to the *lac* promoter, initiating transcription and allowing the cell to use lactose

Figure 8.14 the Growth Rate of E. Coli on Glucose and Lactose



(a) Bacteria growing on glucose as the sole carbon source grow faster than on lactose.



(b) Bacteria growing in a medium containing glucose and lactose first consume the glucose and then, after a short lag time, the lactose. During the lag time, intracellular cAMP increases, the *lac* operon is transcribed, more lactose is transported into the cell, and β-galactosidase is synthesized to break down lactose.

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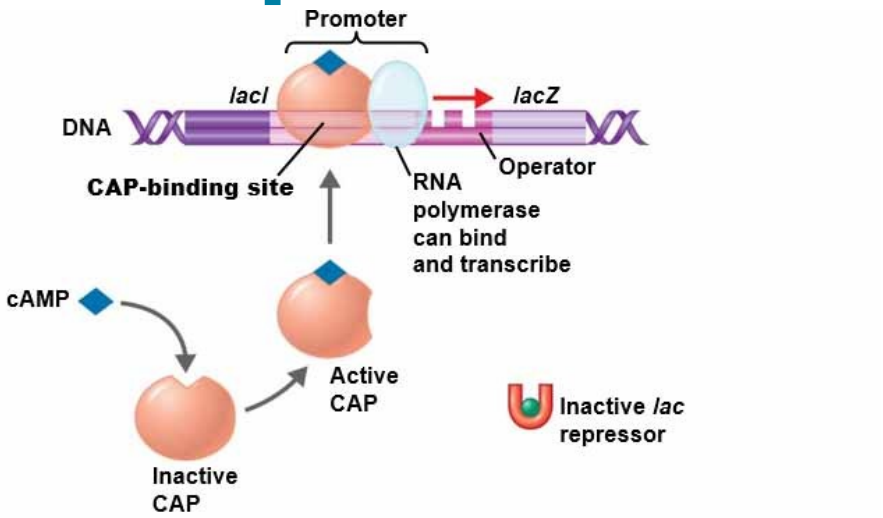
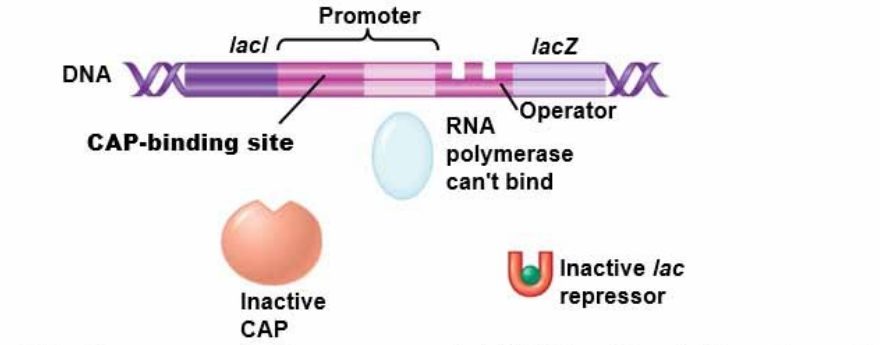
Figure 8.15 Positive Regulation of the Lac Operon



(a) Lactose present, glucose scarce (cAMP level high). If glucose is scarce, the high level of cAMP activates CAP, and the lac operon produces large amounts of mRNA for lactose digestion.



(b) Lactose present, glucose present (cAMP level low). When glucose is present, cAMP is scarce, and CAP is unable to stimulate transcription.

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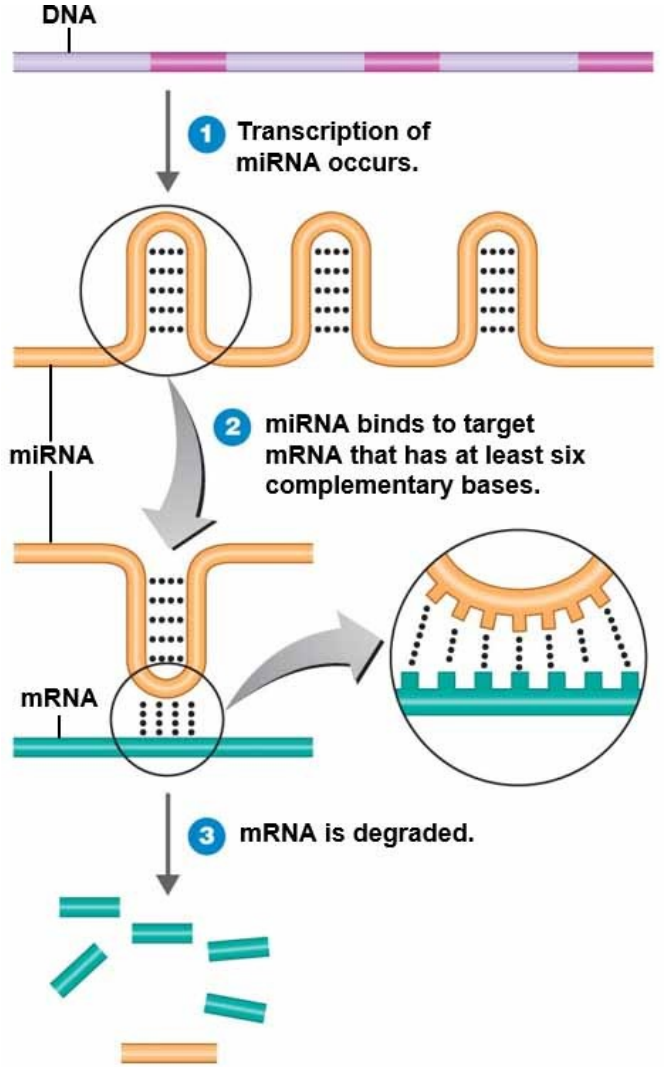
Epigenetic Control

- Methylating nucleotides turns genes off
- Methylated (off) genes can be passed to offspring cells
- Not permanent

Post-Transcriptional Control

- **microRNAs (miRNAs)** base pair with mRNA to make it double-stranded
- Double-stranded RNA is enzymatically destroyed, preventing production of a protein

Figure 8.16 MicroRNAs Control a Wide Range of Activities in Cells



Pearson

Check Your Understanding-5

Check Your Understanding

- What is the role of cAMP in regulating gene expression?
  8-7
- How does miRNA stop protein synthesis?
  8-8

Changes in the Genetic Material

Learning Objectives

8-9 Classify mutations by type.

8-10 Describe two ways mutations can be repaired.

8-11 Describe the effect of mutagens on the mutation rate.

8-12 Outline the methods of direct and indirect selection of mutants.

8-13 Identify the purpose of and outline the procedure for the Ames test.

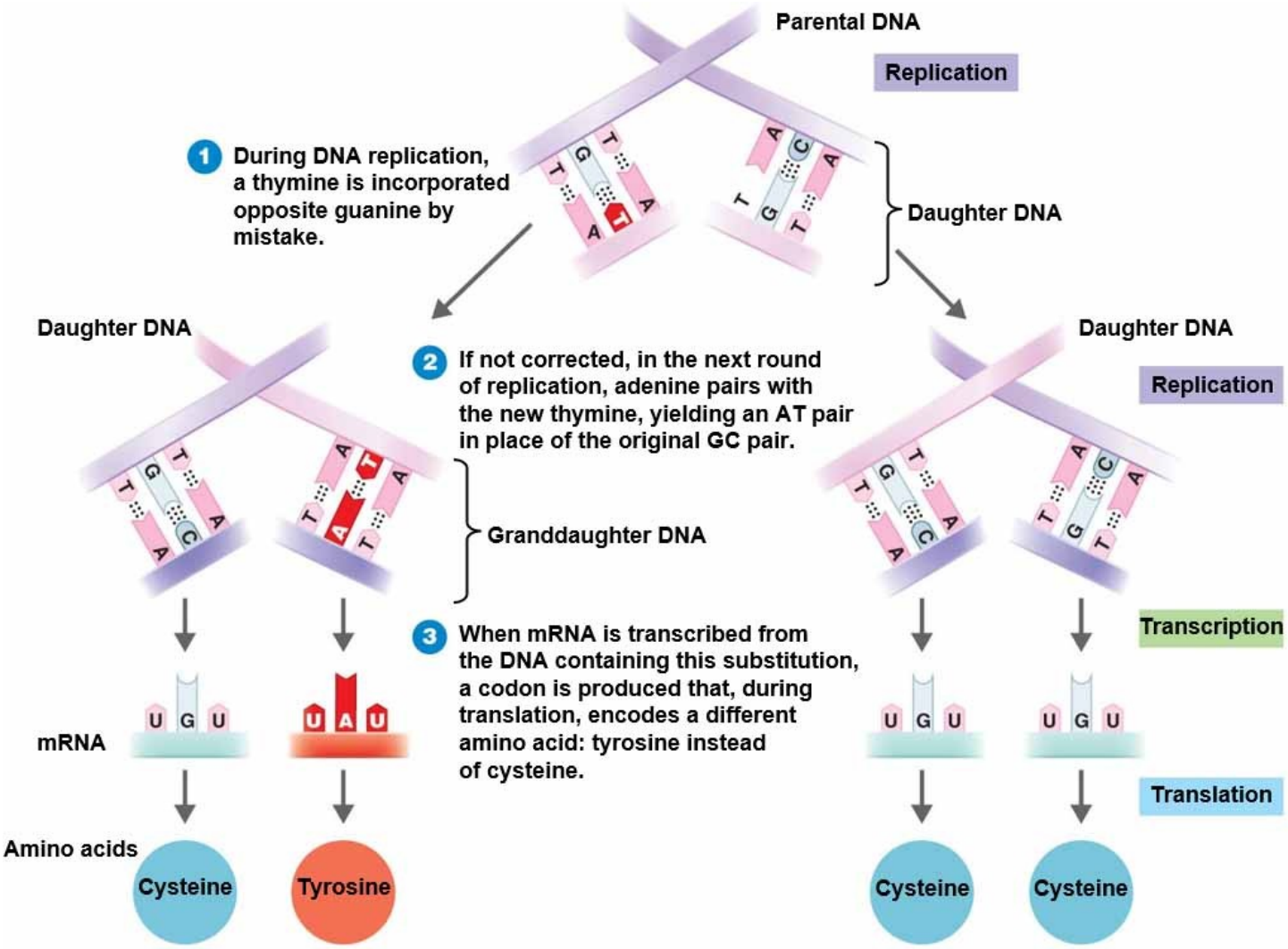
Changes in Genetic Material

- **Mutation:** a permanent change in the base sequence of DNA
- Mutations may be neutral, beneficial, or harmful
- **Mutagens:** agents that cause mutations
- **Spontaneous mutations:** occur in the absence of a mutagen

Types of Mutations (1 of 4)

- **Base substitution** (point mutation)
  - Change in one base in DNA

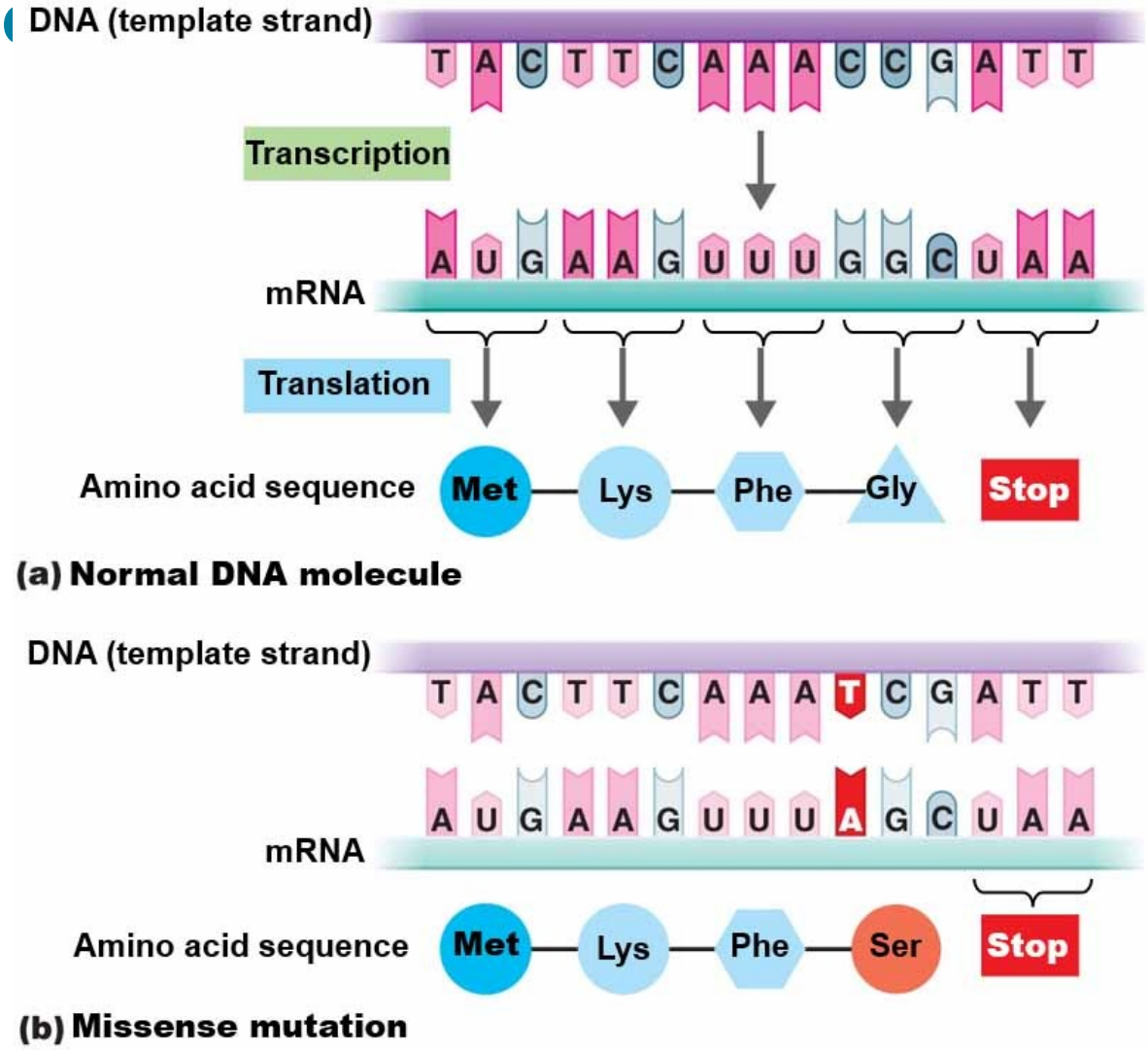
Figure 8.17 Base Substitutions



Types of Mutations (2 of 4)

- **Missense mutation**
  - Base substitution results in change in an amino acid

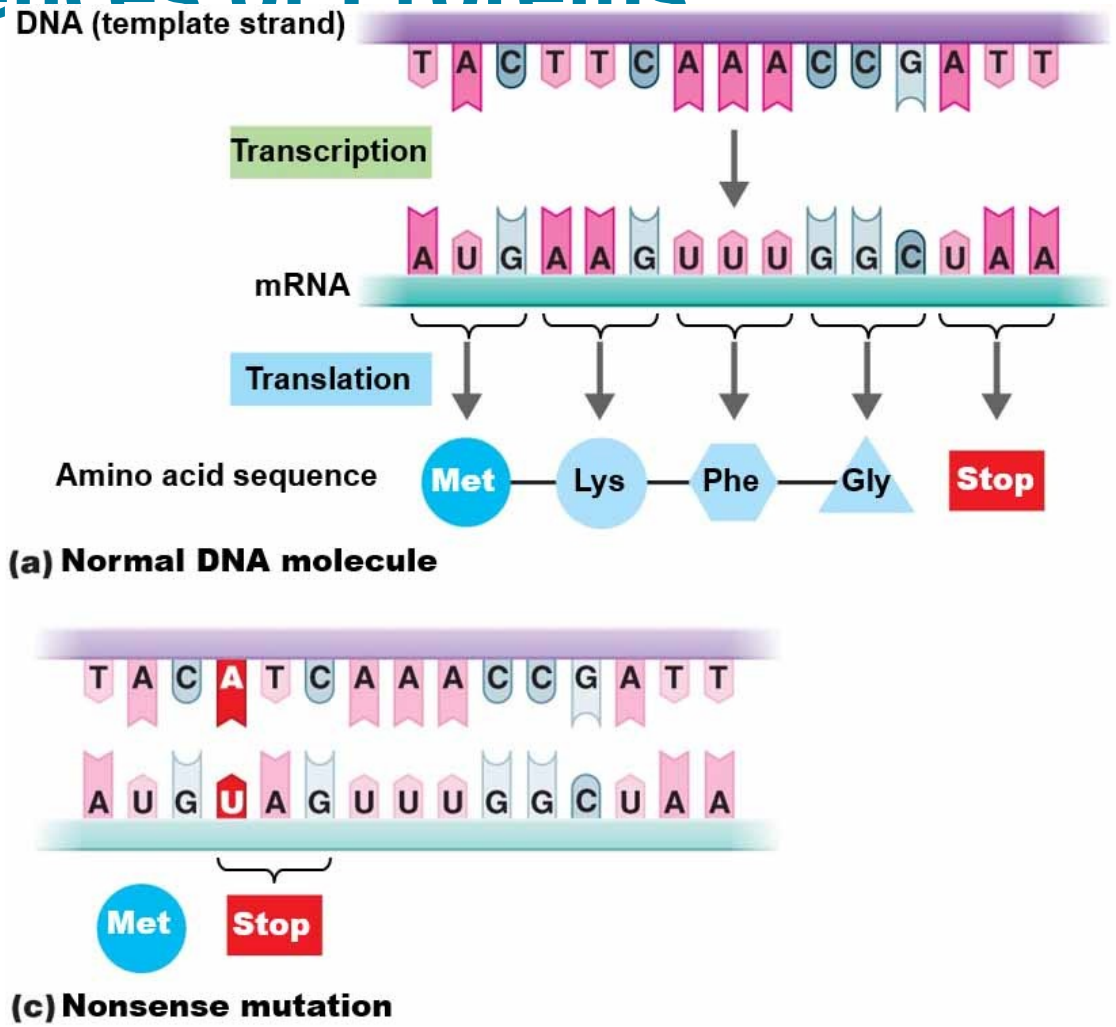
Figure 8.18a-b Types of Mutations and Their Effects on the Amino Acid Sequ



Types of Mutations (3 of 4)

- **Nonsense mutation**
  - Base substitution results in a nonsense (stop) codon

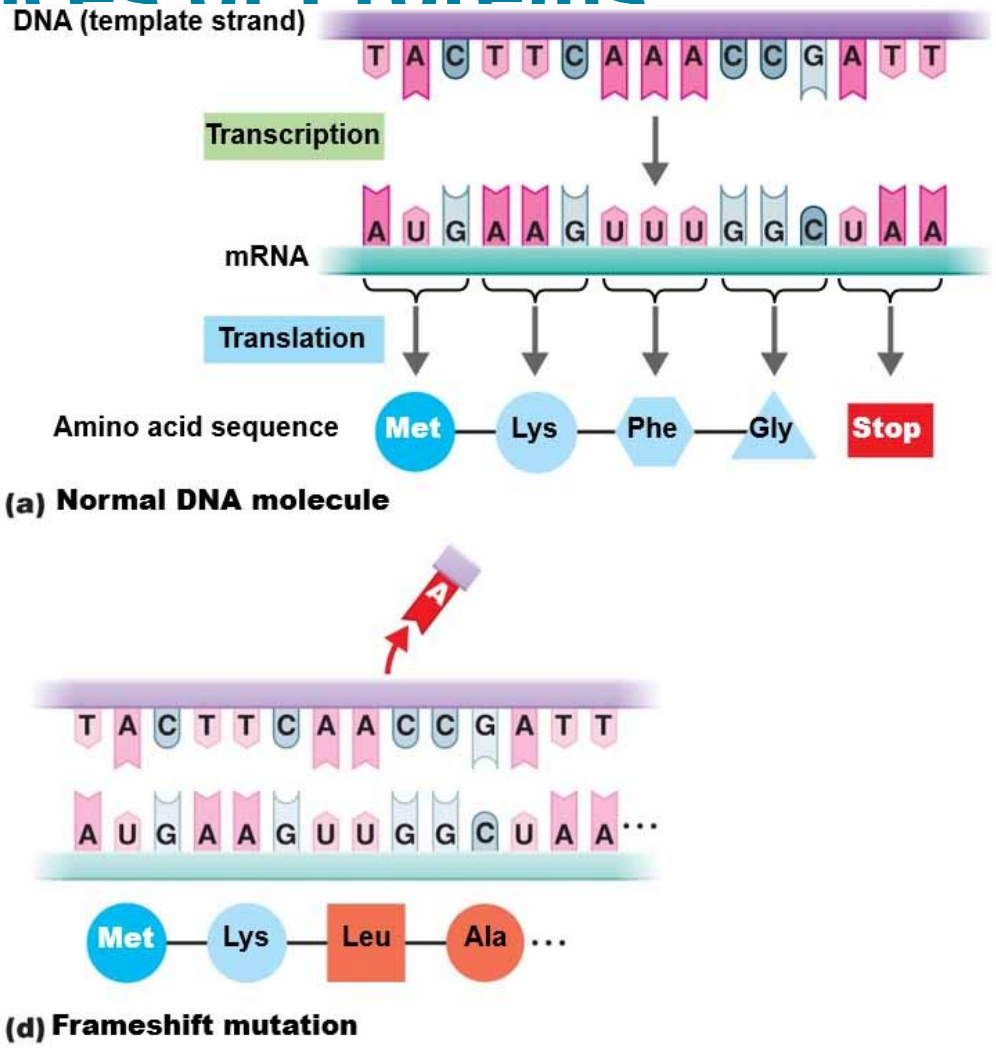
Figure 8.18a-c Types of Mutations and Their Effects on the Amino Acid Sequences of Proteins



Types of Mutations (4 of 4)

- **Frameshift mutation**
  - Insertion or deletion of one or more nucleotide pairs
  - Shifts the translational "reading frame“

Figure 8.18a-d Types of Mutations and Their Effects on the Amino Acid Sequences of Proteins



Check Your Understanding-6

Check Your Understanding

- How can a mutation be beneficial?
  8-9

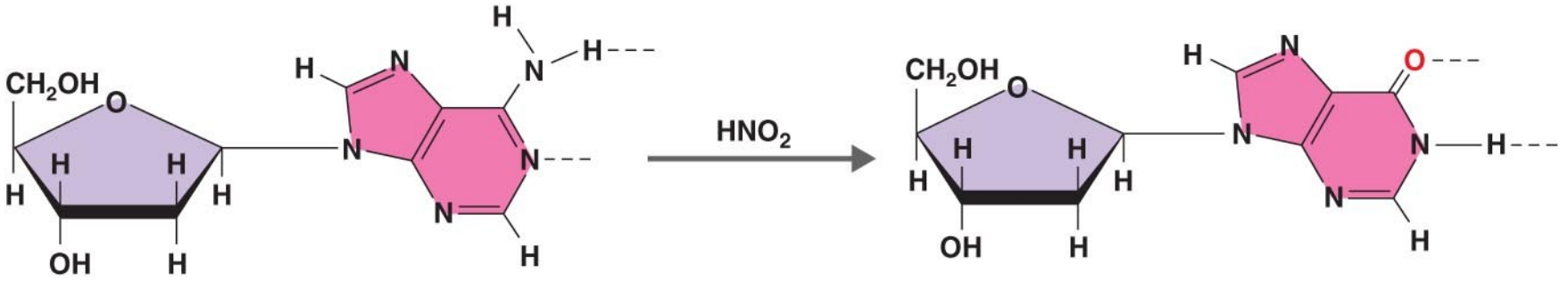
Chemical Mutagens (1 of 2)

- Nitrous acid: causes adenine to bind with cytosine instead of thymine
- **Nucleoside analog:** incorporates into DNA in place of a normal base; causes mistakes in base pairing

Chemical Mutagens (2 of 2)

Animation: Mutagens

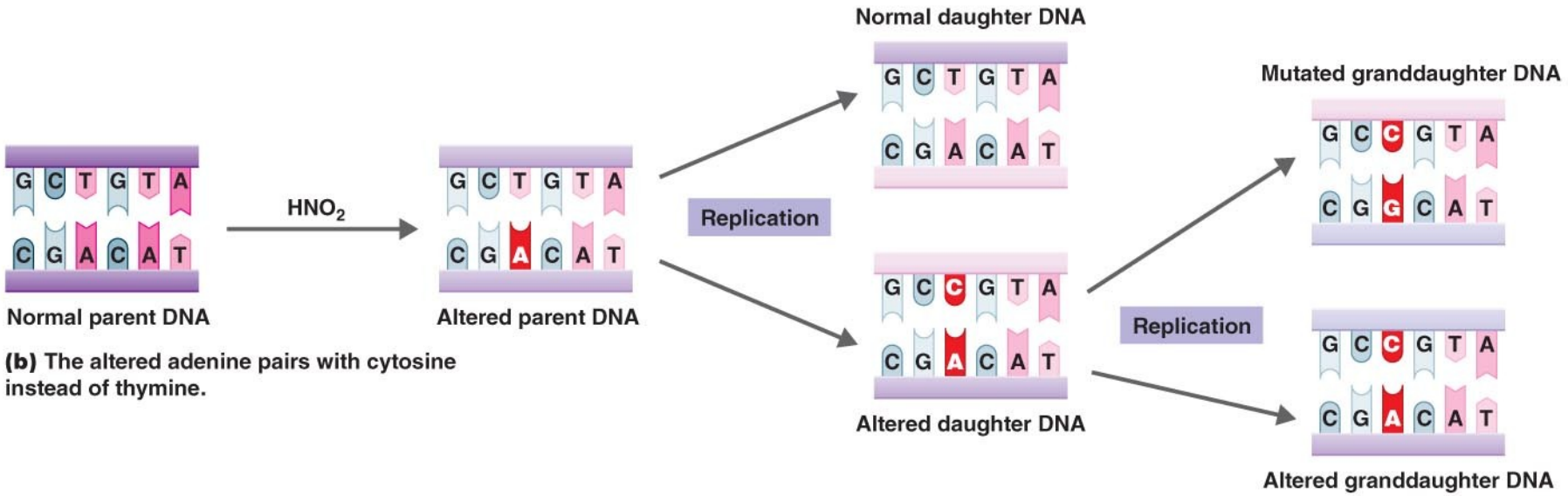
Figure 8.19a Oxidation of Nucleotides Makes a Mutagen



(a) Adenosine nucleoside normally base-pairs by hydrogen bonds with an oxygen and a hydrogen of a thymine or uracil nucleotide.

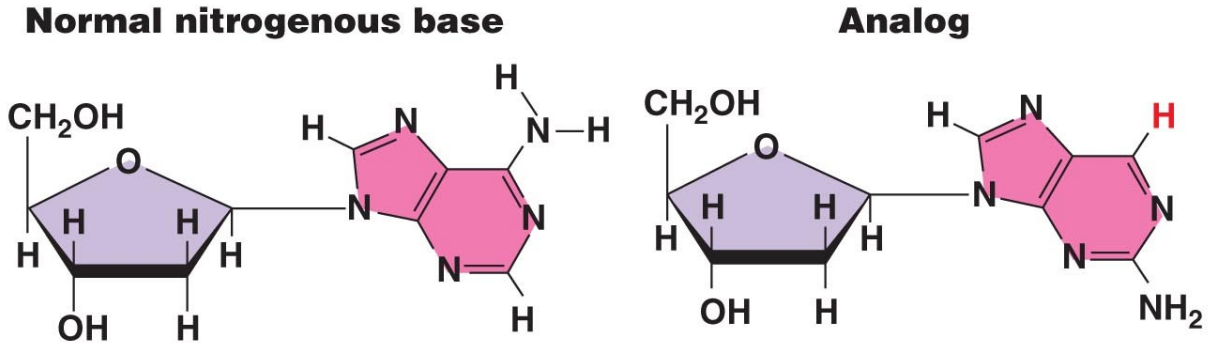
Altered adenine will hydrogen bond with a hydrogen and a nitrogen of a cytosine nucleotide.

Figure 8.19b Oxidation of Nucleotides Makes a Mutagen

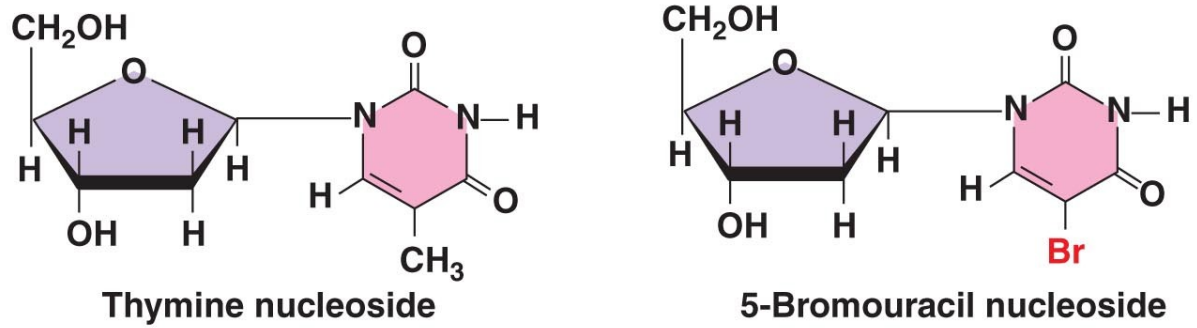


(b) The altered adenine pairs with cytosine instead of thymine.

Figure 8.20 Nucleoside Analogs and the Nitrogenous Bases They Replace



(a) The 2-aminopurine is incorporated into DNA in place of adenine but can pair with cytosine, so an AT pair becomes a CG pair.



(b) The 5-bromouracil is used as an anticancer drug because it is mistaken for thymine by cellular enzymes but pairs with cytosine. In the next DNA replication, an AT pair becomes a GC pair.

Radiation (1 of 3)

- Ionizing radiation (X rays and gamma rays) causes the formation of ions that can oxidize nucleotides and break the deoxyribose-phosphate backbone
- UV radiation causes thymine dimers

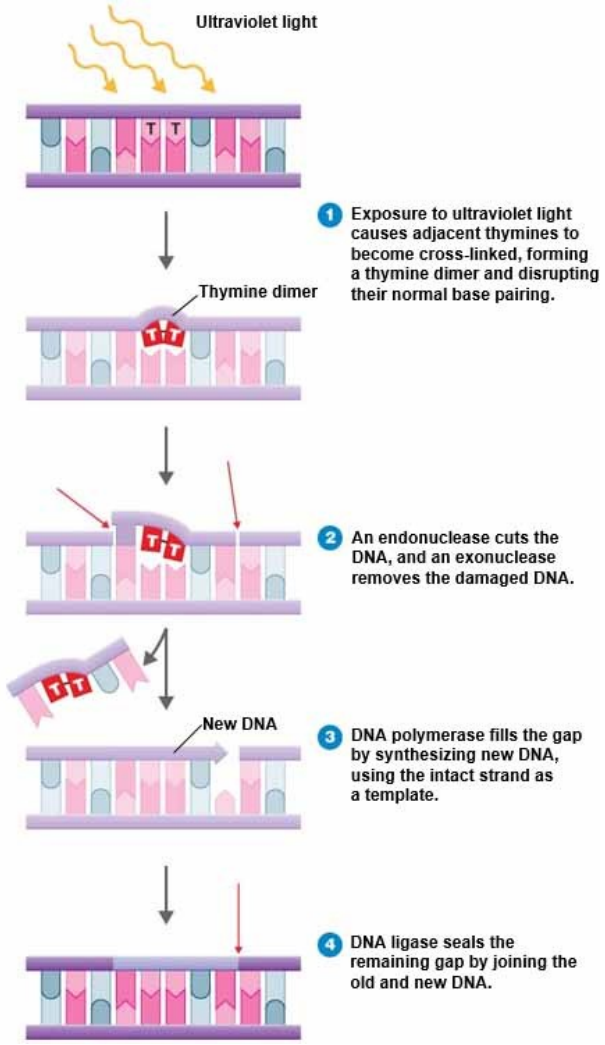
Radiation (2 of 3)

- **Photolyases** separate thymine dimers
- **Nucleotide excision repair:** Enzymes cut out incorrect bases and fill in correct bases

Radiation (3 of 3)

Animation: Mutations: Repair

Figure 8.21 the Creation and Repair of a Thymine Dimer Caused by Ultraviolet Light



Pearson

The Frequency of Mutation (1 of 2)

- Spontaneous mutation rate = 10^{-9} in replicated base pairs or 10^{-6} in replicated genes
- Mutagens increase the mutation rate 10^{-5} or 10^{-3} per replicated gene

The Frequency of Mutation (2 of 2)

PLAY **Animation: Mutations: Types**

Check Your Understanding-7

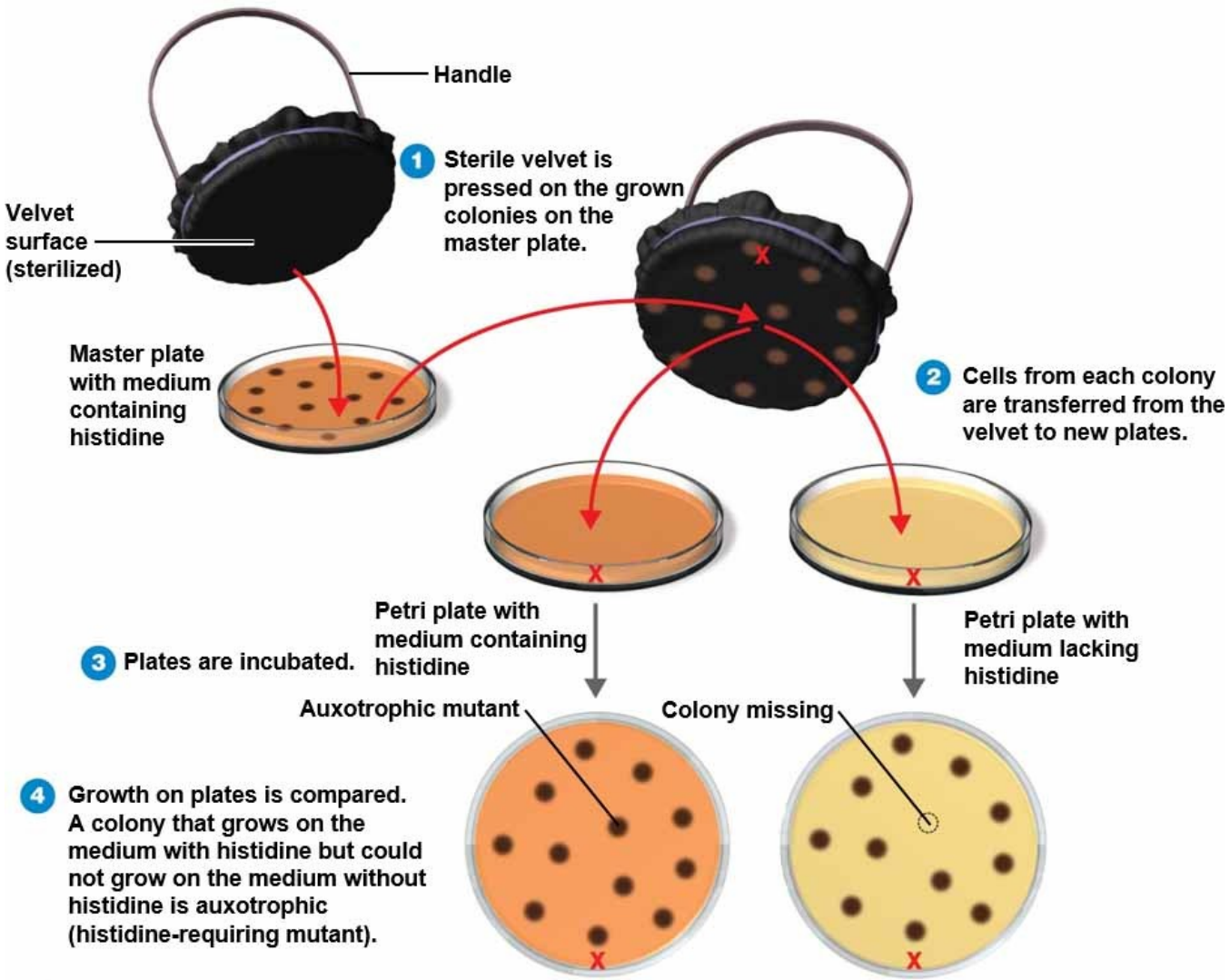
Check Your Understanding

- ✓ How can mutations be repaired?
  8-10
- ✓ How do mutagens affect the mutation rate?
  8-11

Identifying Mutants

- **Positive (direct) selection** detects mutant cells because they grow or appear different than unmutated cells
- **Negative (indirect) selection** detects mutant cells that cannot grow or perform a certain function
- **Auxtotroph:** mutant that has a nutritional requirement absent in the parent
  - Use of **replica plating**

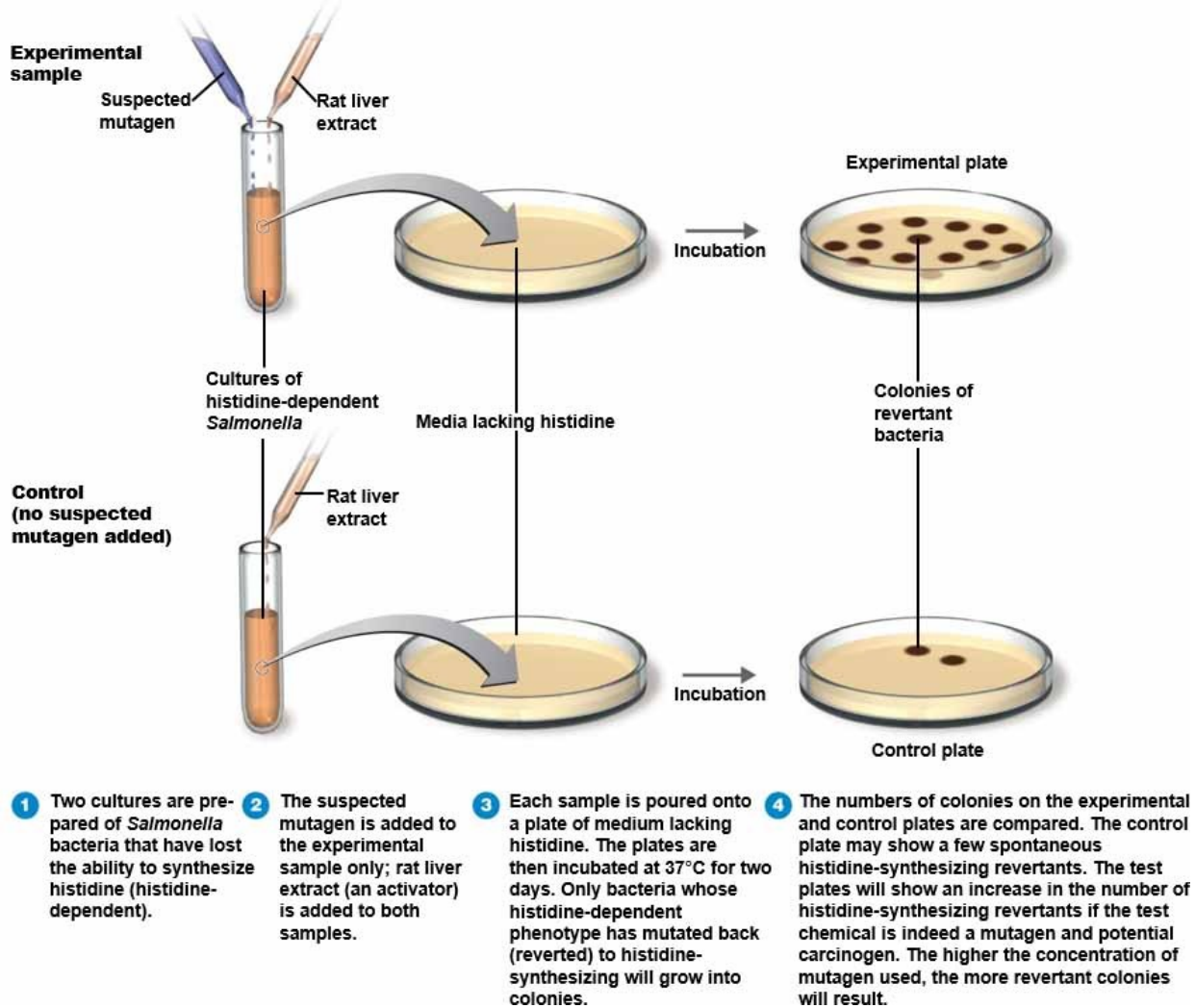
Figure 8.22 Replica Plating



Identifying Chemical Carcinogens (1 of 2)

- The **Ames test** exposes mutant bacteria to mutagenic substances to measure the rate of reversal of the mutation
  - Indicates degree to which a substance is mutagenic

Figure 8.23 the Ames Reverse Gene Mutation Test



Pearson

Check Your Understanding-8

Check Your Understanding

- ✓ How would you isolate an antibiotic-resistant bacterium? An antibiotic-sensitive bacterium? 8-12
- ✓ What is the principle behind the Ames test? 8-13

Genetic Transfer and Recombination (1 of 4)

Learning Objectives

8-14 Differentiate horizontal and vertical gene transfer.

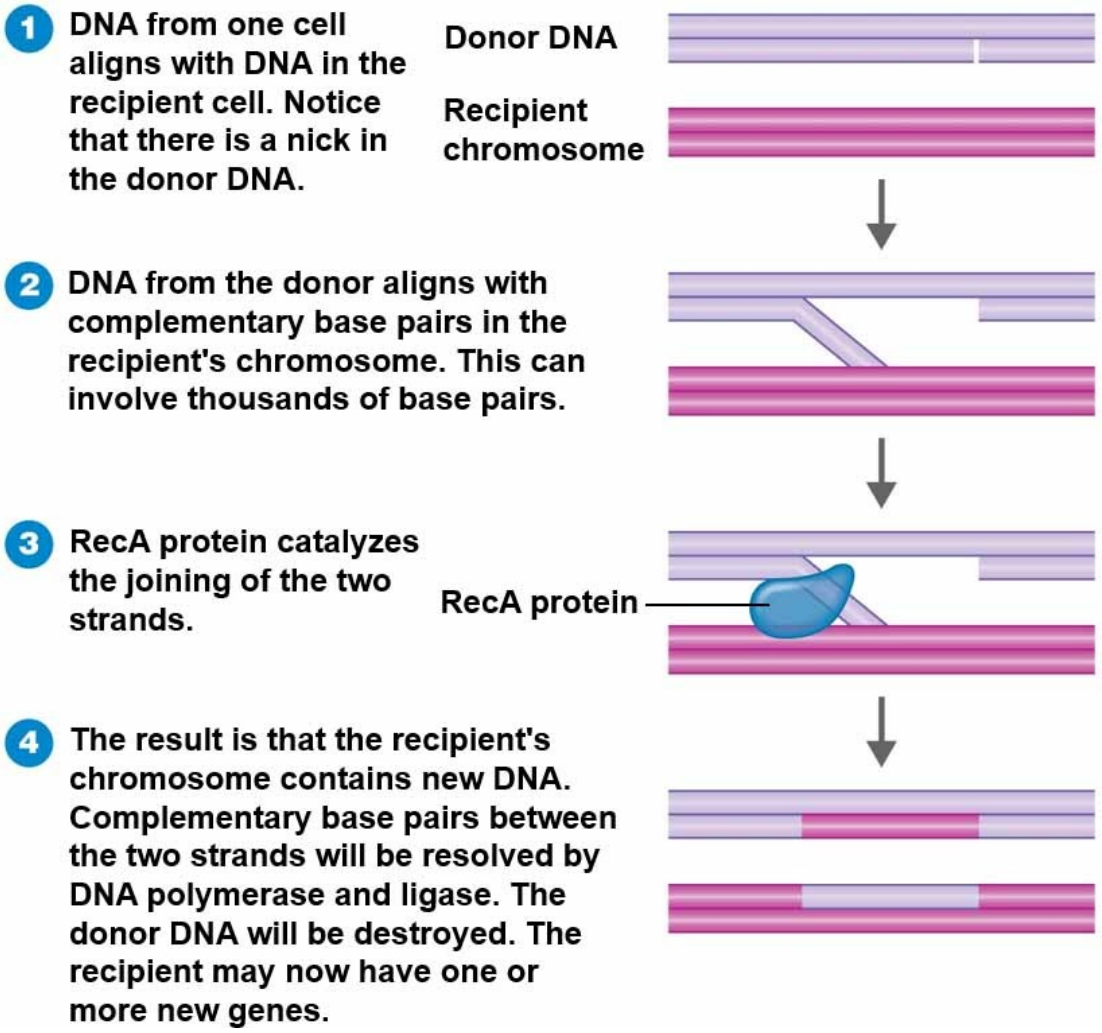
8-15 Compare the mechanisms of genetic recombination in bacteria.

8-16 Describe the functions of plasmids and transposons.

Genetic Transfer and Recombination (2 of 4)

- **Genetic recombination:** exchange of genes between two DNA molecules; creates genetic diversity
- **Crossing over:** Two chromosomes break and rejoin, resulting in the insertion of foreign DNA into the chromosome

Figure 8.24 Genetic Recombination by Crossing Over



Genetic Transfer and Recombination (3 of 4)

- **Vertical gene transfer:** transfer of genes from an organism to its offspring
- **Horizontal gene transfer:** transfer of genes between cells of the same generation

Genetic Transfer and Recombination (4 of 4)

PLAY **Animation: Horizontal Gene Transfer: Overview**

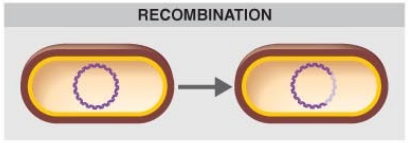
Transformation in Bacteria (1 of 2)

- **Transformation:** genes transferred from one bacterium to another as "naked" DNA

Transformation in Bacteria (2 of 2)

PLAY **Animation: Transformation**

Figure 8.25 Griffith's Experiment Demonstrating Genetic Tr



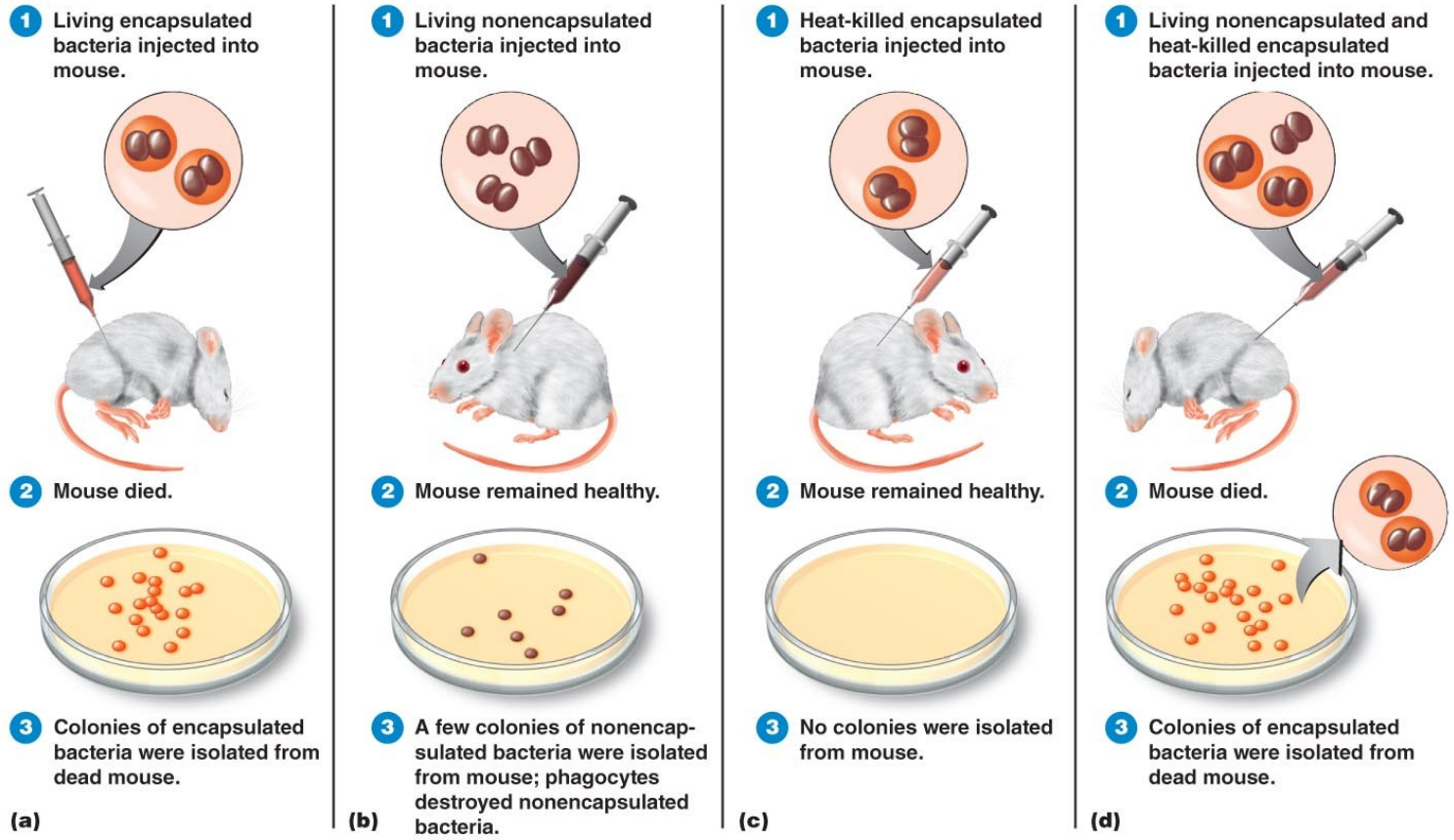
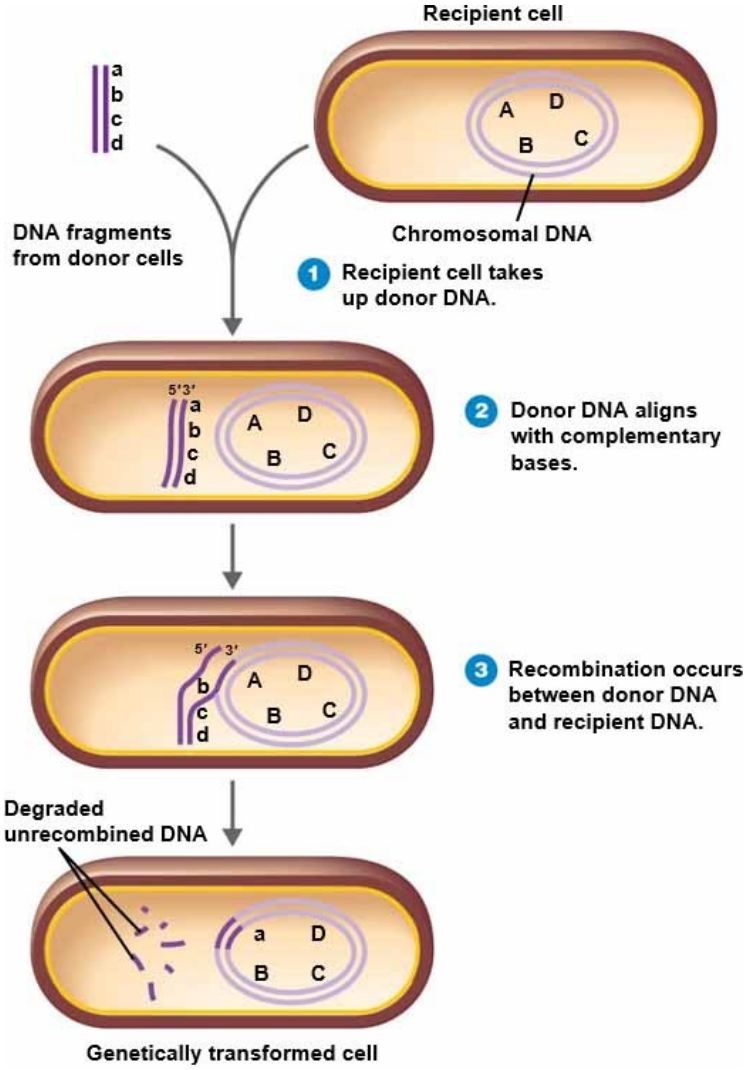


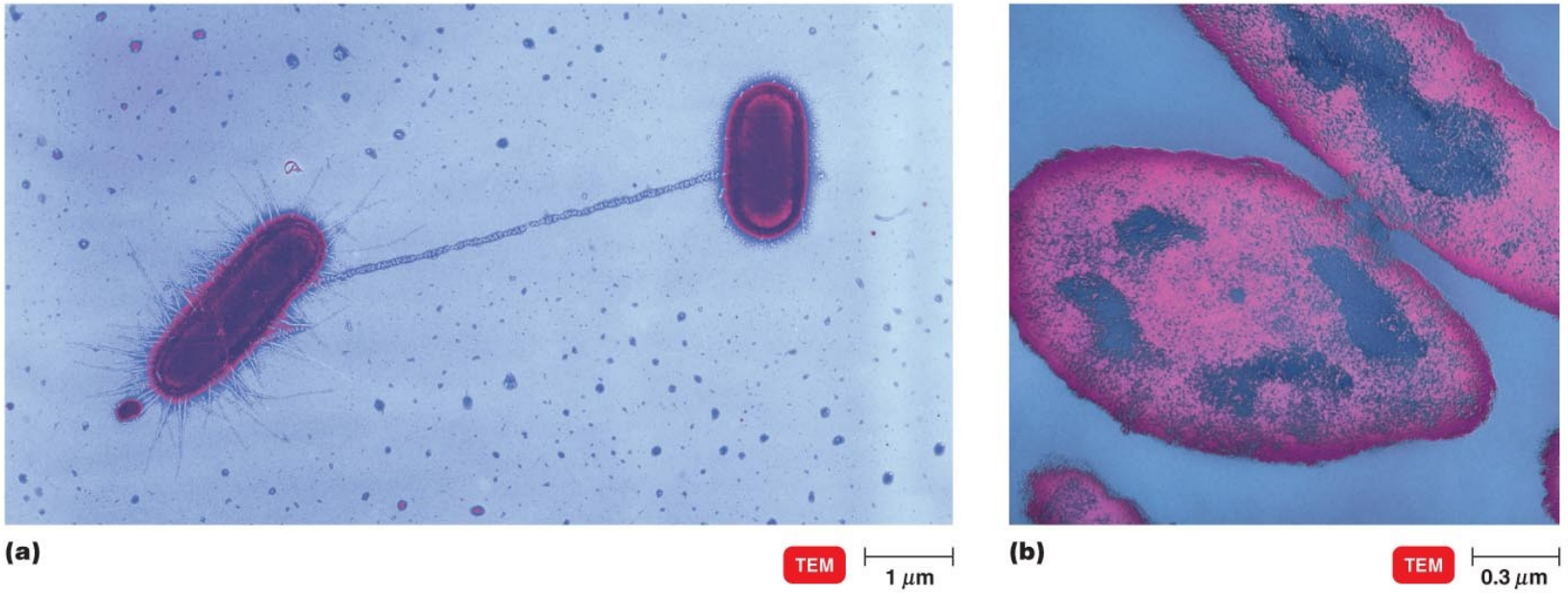
Figure 8.26 the Mechanism of Genetic Transformation in Bacteria



Conjugation in Bacteria (1 of 7)

- **Conjugation:** plasmids transferred from one bacterium to another
- Requires cell-to-cell contact via sex pili

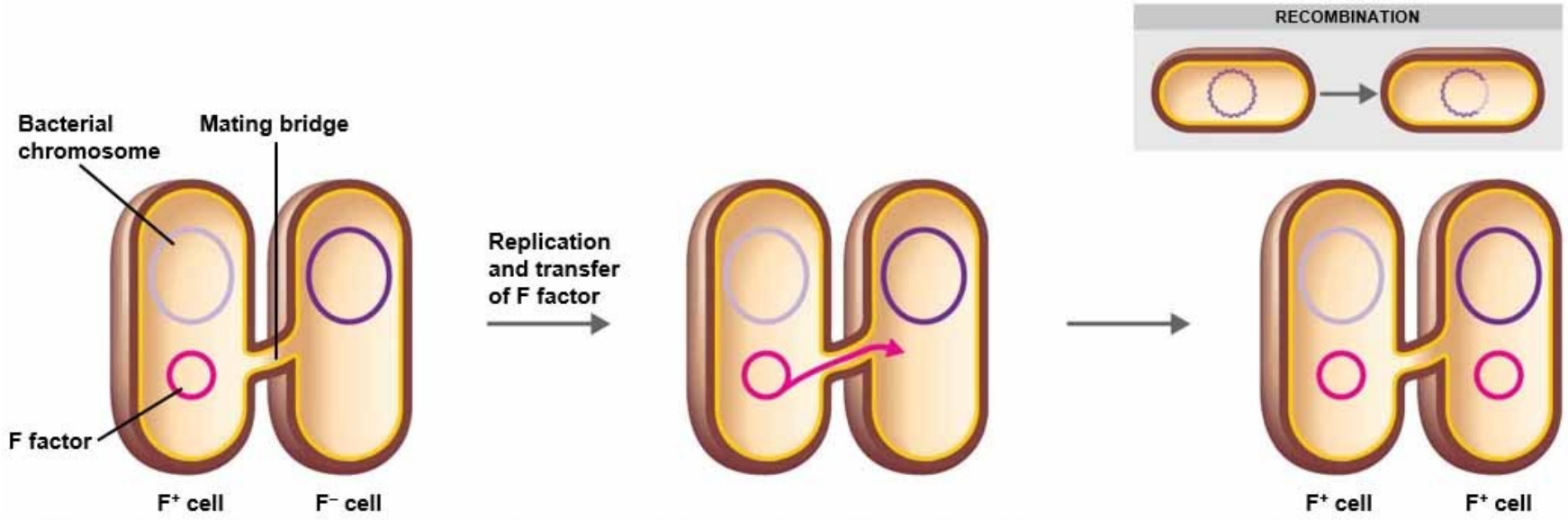
Figure 8.27 Bacterial Conjugation



Conjugation in Bacteria (2 of 7)

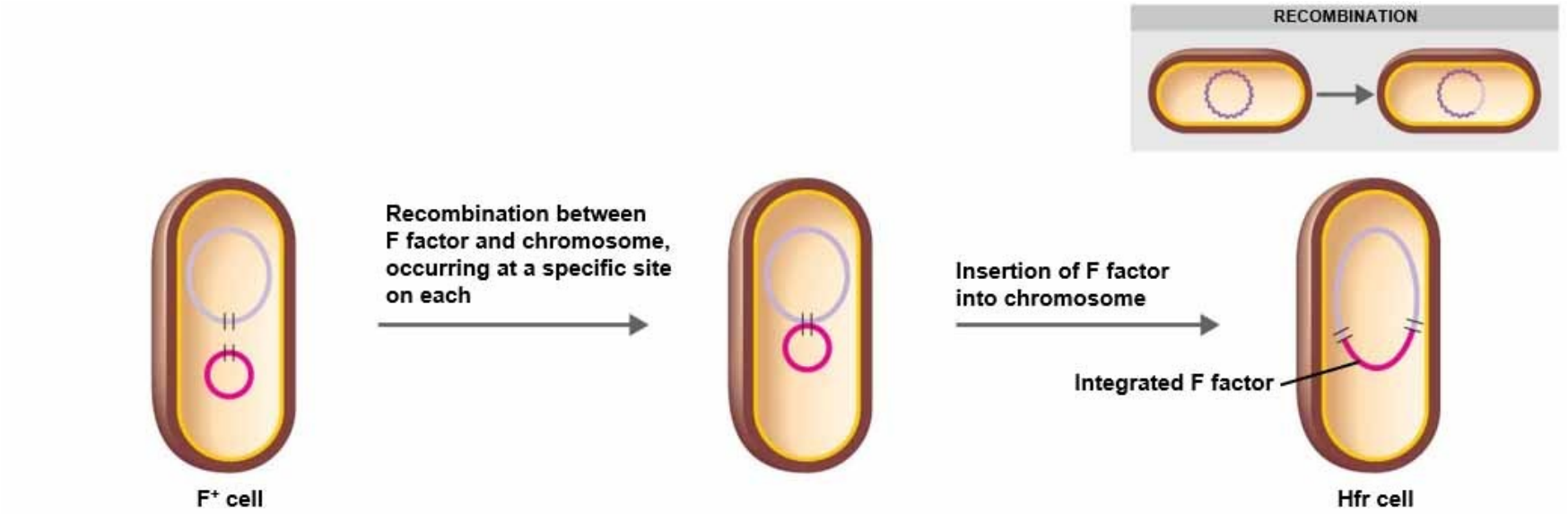
- Donor cells carry the plasmid (F factor) and are called F^+ cells
- **Hfr cells** contain the F factor on the chromosome

Figure 8.28a Conjugation in E. coli



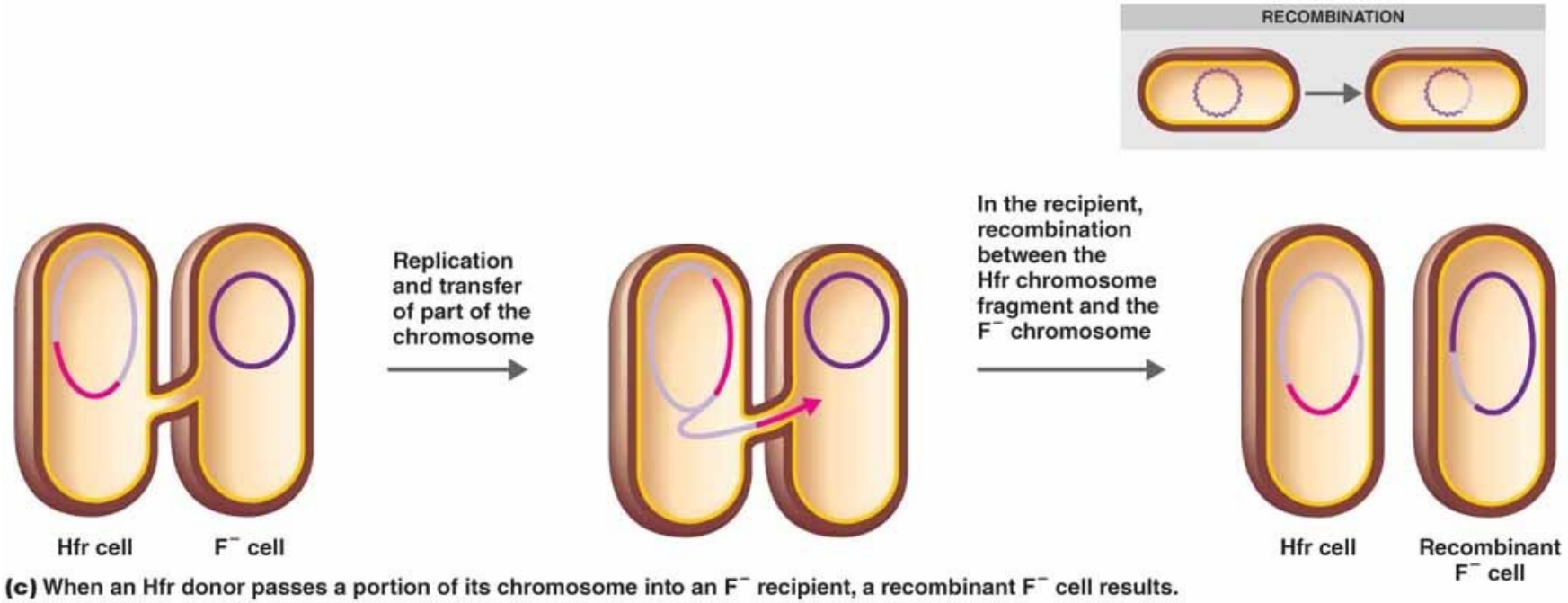
(a) When an F factor (a plasmid) is transferred from a donor (F^+) to a recipient (F^-), the F^- cell is converted to an F^+ cell.

Figure 8.28b Conjugation in E. coli



(b) When an F factor becomes integrated into the chromosome of an F^+ cell, it makes the cell a high frequency of recombination (Hfr) cell.

Figure 8.28c Conjugation in E. coli



(c) When an Hfr donor passes a portion of its chromosome into an F^- recipient, a recombinant F^- cell results.

Conjugation in Bacteria (3 of 7)

PLAY **Animation: Conjugation: F Factor**

Conjugation in Bacteria (4 of 7)

PLAY **Animation: Conjugation: Overview**

Conjugation in Bacteria (5 of 7)

PLAY **Animation: Conjugation: Hfr Conjugation**

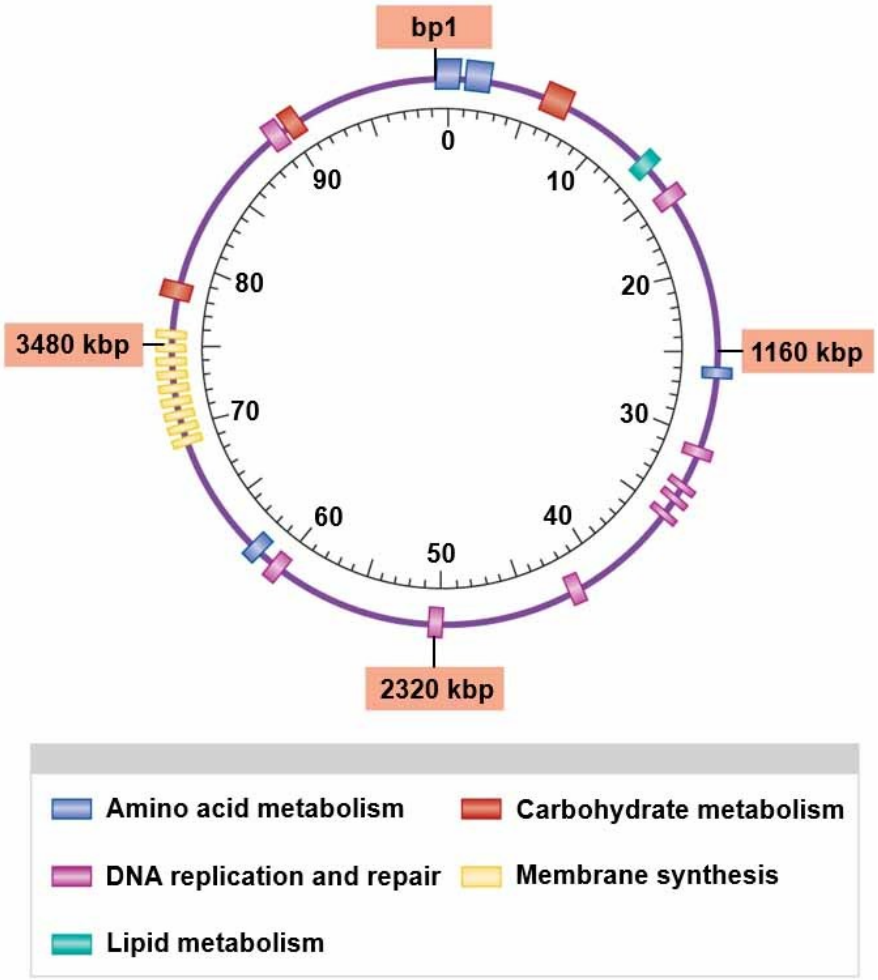
Conjugation in Bacteria (6 of 7)

- Conjugation can be used to map the location of genes on a chromosome

Conjugation in Bacteria (7 of 7)

PLAY **Animation: Conjugation: Chromosome Mapping**

Figure 8.29 a Genetic Map of the Chromosome of E. Coli



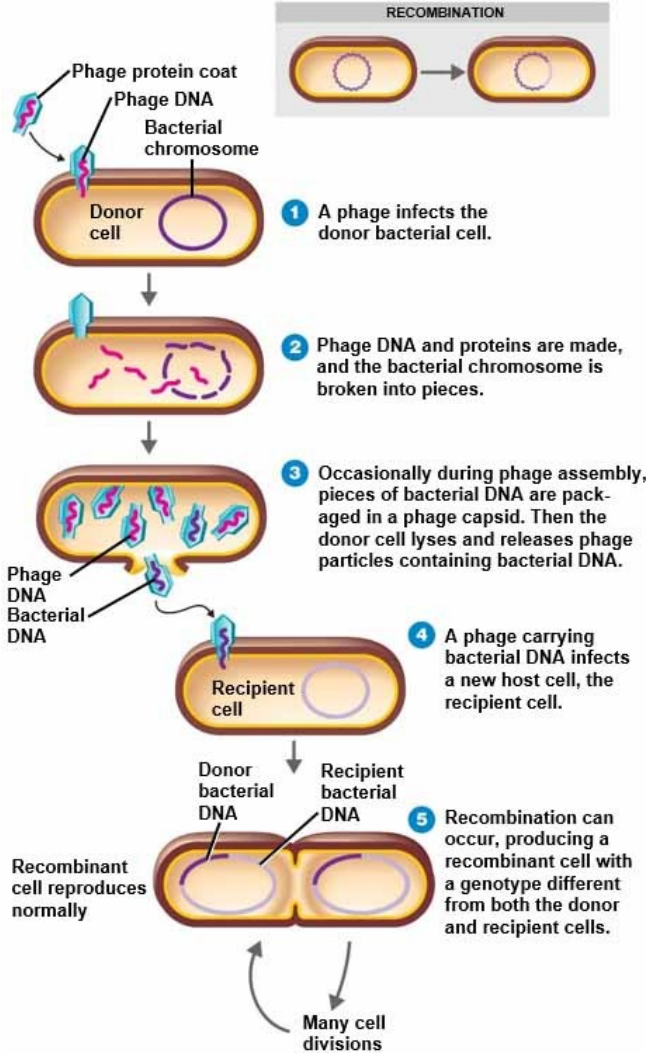
Transduction in Bacteria (1 of 3)

- DNA is transferred from a donor cell to a recipient via a **bacteriophage**
- **Generalized transduction:** Random bacterial DNA is packaged inside a phage and transferred to a recipient cell
- **Specialized transduction:** Specific bacterial genes are packaged inside a phage and transferred to a recipient cell

Transduction in Bacteria (2 of 3)

PLAY **Animation: Transduction: Generalized Transduction**

Figure 8.30 Transduction by a Bacteriophage



Transduction in Bacteria (3 of 3)

PLAY **Animation: Transduction: Specialized Transduction**

Check Your Understanding-9

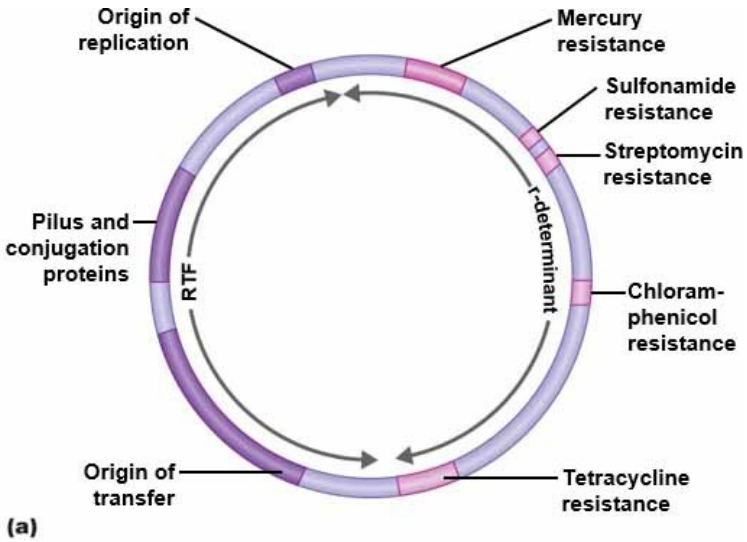
Check Your Understanding

- ✓ Differentiate horizontal and vertical gene transfer. 8-14
- ✓ Compare conjugation between the following pairs: F+ × F−, Hfr × F− 8-15

Plasmids (1 of 2)

- **Plasmids** are self-replicating circular pieces of DNA
- 1 to 5% the size of a bacterial chromosome
- Often code for proteins that enhance the pathogenicity of a bacterium

Figure 8.31 R Factor, a Type of Plasmid



Plasmids (2 of 2)

- **Conjugative plasmid:** carries genes for sex pili and transfer of the plasmid
- **Dissimilation plasmids:** encode enzymes for the catabolism of unusual compounds
- **Resistance factors (R factors):** encode antibiotic resistance

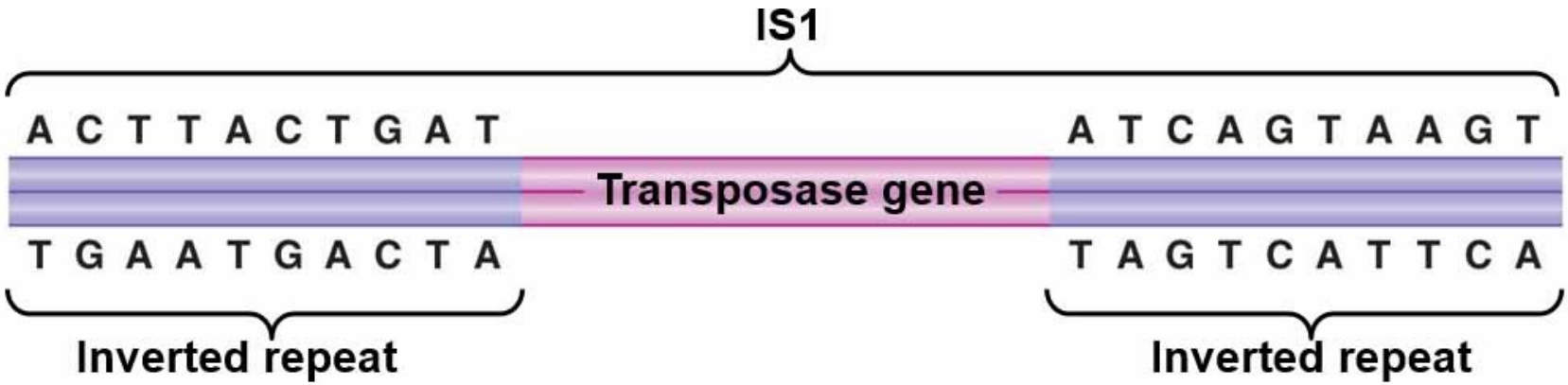
Transposons (1 of 4)

- **Transposons** are segments of DNA that can move from one region of DNA to another
- **Contain insertion sequences (IS)** that code for transposase that cuts and reseals DNA
- Complex transposons carry other genes (e.g, in antibiotic resistance)

Transposons (2 of 4)

PLAY **Animation: Transduction: Overview**

Figure 8.32a Transposons and Insertion



(a) An insertion sequence (IS), the simplest transposon, contains a gene for transposase, the enzyme that catalyzes transposition. The tranposase gene is bounded at each end by inverted repeat sequences that function as recognition sites for the transposon. IS1 is one example of an insertion sequence, shown here with simplified IR sequences.

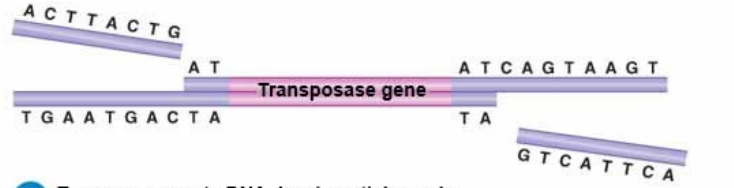
Transposons (3 of 4)

PLAY **Animation: Transduction: Insertion Sequences**

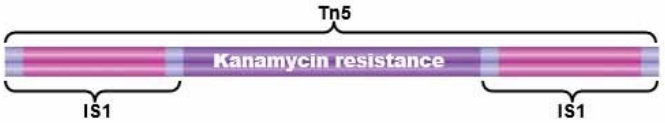
Transposons (4 of 4)

PLAY **Animation: Transduction: Complex Transposons**

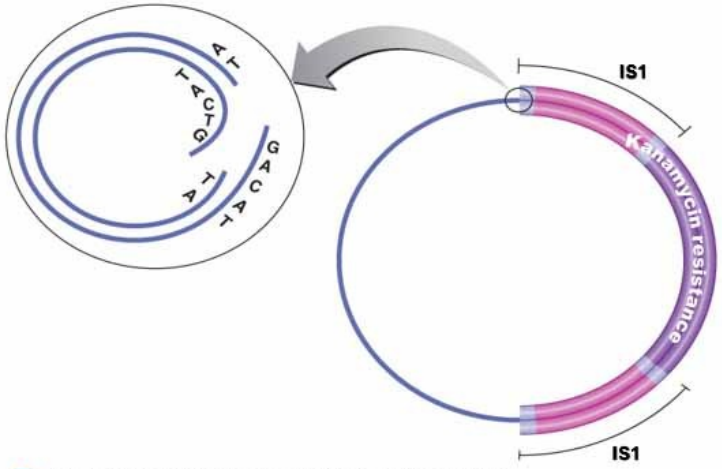
Figure 8.32b-c Transposons and Insertion



1 Transposase cuts DNA, leaving sticky ends.



(b) Complex transposons carry other genetic material in addition to transposase genes. The example shown here, Tn5, carries the gene for kanamycin resistance and has complete copies of the insertion sequence IS1 at each end.



2 Sticky ends of transposon and target DNA anneal.

(c) Insertion of the transposon Tn5 into R100 plasmid

Check Your Understanding-10

Check Your Understanding

- What types of genes do plasmids carry?
  8-16

Genes and Evolution (1 of 2)

Learning Objective

8-17 Discuss how genetic mutation and recombination provide material for natural selection to act upon.

Genes and Evolution (2 of 2)

- Mutations and recombination create cell diversity
- Diversity is the raw material for evolution
- Natural selection acts on populations of organisms to ensure the survival of organisms fit for a particular environment

Check Your Understanding-11

Check Your Understanding

- ✓ Natural selection means that the environment favors survival of some genotypes. From where does diversity in genotypes come?
  8-17